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NATIONAL DAM SAFETY PROGRAM. FRANCOIS LAKE DAM (MO 31389), UPPE--ETC(U)
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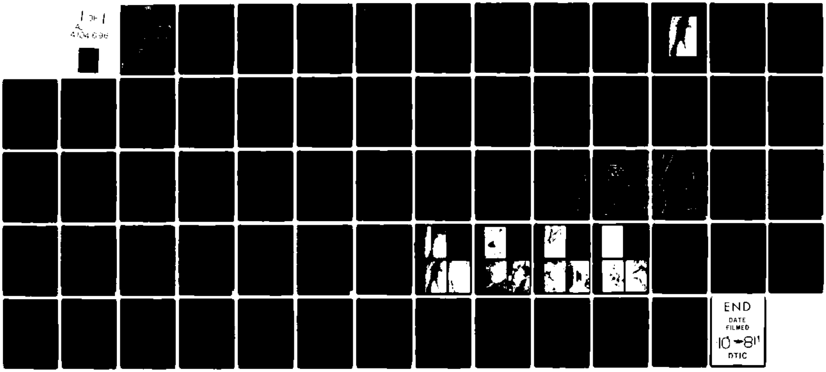

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AD A104696

FRANCOIS LAKE DAM

JEFFERSON COUNTY, MISSOURI

MO 31389

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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UPPER MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

FRANCOIS LAKE DAM

JEFFERSON COUNTY, MISSOURI

MO 31389

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1981

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Francois Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Francois Lake Dam (MO 31389).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillways will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 28 APR 1981 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 29 APR 1981 Date

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FRANCOIS LAKE DAM

MISSOURI INVENTORY NO. 31389

JEFFERSON COUNTY, MISSOURI

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

CORPS OF ENGINEERS

APRIL 1981

HS-8088

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Francois Lake Dam
State Located:	Missouri
County Located:	Jefferson
Stream:	Subtributary of Mississippi River
Date of Inspection:	6 November 1980

The Francois Lake Dam, which according to the St. Louis District, Corps of Engineers, is of high hazard potential, was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Enginers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses an inordinate danger to human life or property. Evaluation of this dam was performed in accordance with the "Phase I" investigation procedures prescribed in "Recommended Guidelines for Safety Inspection of Dams", dated May 1975.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be less than satisfactory. Several items were noticed during the inspection which are considered to have an adverse effect on the overall safety and future operation of the dam, the most pronounced being the rather extensive erosion that has occurred across the downstream face of the dam. Numerous gullies up to 18 inches in depth along with several gullies approximately 4 feet deep were noted in the downstream face near the toe of the dam. Other deficiencies include such items as erosion of the upstream face, tall grass and weeds on the upstream face that may conceal animal burrows, and major areas of the dam crest and downstream face that have no turf cover, or which are sparsely covered, to prevent erosion as well as the lack of a durable form of erosion protection, such as riprap, along the upstream face of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Francois Lake Dam, which according to Table 1 of the guidelines, is classified as small in size and of high hazard potential, is specified, according to Table 3 of the guidelines for a high hazard dam of small size, to be a minimum of one-half the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the fact that seven dwellings are located within the potential flood damage zone approximately one-half mile downstream of the dam, and that the valley between the dam and these dwellings is narrow and moderately steep, it is recommended that the spillway for this dam be designed for the entire PMF. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude or a storm of one-half PMF magnitude without overtopping the dam. The spillway is capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 19 percent of the PMF. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be three miles. Within the potential flood damage zone are ten dwellings, including four mobile homes, a commercial establishment, and Interstate Highway 55.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein. The item concerning increasing spillway capacity should be pursued on a high priority basis.

Ralph E. Sauthoff
Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.
Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW FRANCOIS LAKE DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FRANCOIS LAKE DAM - MO 31389

TABLE OF CONTENTS

LIST OF PLATES

APPENDIX A - INSPECTION PHOTOGRAPHS

APPENDIX B - HYDROLOGIC AND HYDRAULIC ANALYSES

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FRANCOIS LAKE DAM - MO 31389

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Francois Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses an inordinate danger to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams", dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Francois Lake Dam is an earthfill type embankment rising approximately 38 feet above the natural streambed at the downstream toe of the barrier. The slope of the upstream face (above the waterline) varies from about 1v on 2.6h near the dam crest to about 1v on 1.3h at the waterline, although this may be a local condition since it is evident that some erosion of the upstream face just above the normal waterline has occurred. The slope of the downstream face is quite irregular, varying from about 1v on 1.2h near the mid-height of the dam to 1v on 2.2h at the toe of the main body of the dam. The crest of the dam is approximately 20 feet wide and a berm on the order of 22 feet in width is located about 5 feet above the downstream toe of the dam near the center of the structure. Between abutments, the dam curves outwardly away from the lake. The length of the dam is approximately 460 feet. A plan and profile of the dam is shown on Plate 3 and a cross-section of the dam, at about the location of the original stream on which the dam was constructed, is shown on Plate 4. At normal pool elevation, the reservoir impounded by the dam occupies approximately 3.4 acres. There is no drawdown facility to dewater the lake. An overview photo of the Francois Lake Dam is shown following the preface at the beginning of the report.

The dam has both a principal and an emergency spillway. The principal spillway, a 12-inch diameter asbestos-cement pipe culvert, is located at the left, or north, end of the dam. The emergency spillway, a 30-inch diameter corrugated metal pipe culvert, is also located at the left end of the dam, approximately 33 feet (measuring along the centerline of the dam) north of the principal spillway. The upstream face of the dam is protected by concrete slope paving in the immediate vicinity of and about both pipes. The length of the 12-inch pipe is approximately 63 feet and the length of the 30-inch pipe is about 65 feet. An excavated earth, irregular trapezoidal section, outlet channel is common to both spillway pipes. The outlet channel closely follows the hillside of the left abutment through the exit section joining the original stream channel at a point approximately 150 feet downstream of the toe of the dam. A low bank on the order of 2 feet in height at the dam serves to confine flow to the channel and prevent spillway releases from impinging upon the dam. Profiles of the two spillway pipes are also shown on Plate 4.

A second dam impounding a lake of approximately 1.8 acres at spillway crest elevation, is located approximately 950 feet upstream of the Francois Lake Dam. A small pond of less than one-half acre in area abuts the downstream face of this dam, and a second small pond also less then one-half acre in area, lies approximately 400 feet upstream of the upper reservoir. The relative locations of the two lakes and the ponds upstream and downstream of the upper reservoir is shown on the Lake Watershed Map, Plate 2. The length of the upstream dam is approximately 206 feet, and the height of the dam is probably on the order of 30 feet. The spillway, an excavated earth type section, is located at the right end of the dam. The outlet channel for the spillway joins the pond located immediately below the dam. Ditches, located at the abutments opposite the ends of the dam, intercept hillside runoff and carry the drainage to the lower Francois Lake. A profile and cross-section of the upstream reservoir dam are presented on Plate 5, and details of the spillway are shown on Plate 6.

b. Location. The dam is located on an unnamed subtributary of the Mississippi River, about 1.9 miles southwest of the intersection of Highway M and Interstate Highway 55, and approximately 1.7 miles southwest of the community of Barnhart, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southwest one-quarter of Section 36, Township 42 North, Range 5 East, within Jefferson County.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as small (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. Hazard Classification. The Francois Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends three miles downstream of the dam. Within the possible damage zone are ten dwellings, including four mobile homes, a commercial establishment, and Interstate Highway 55. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e. Ownership. The lake and dam are owned by David Francois. Mr. Francois' address is 10939 Manchester Avenue, St. Louis, Missouri 63122.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. According to the Owner, the dam was originally constructed in 1976 by the J. H. Berra Construction Company of St. Louis, Missouri. The Owner reported that, in 1979, the dam was raised approximately 5 feet, the crest was widened to about 20 feet, and a pipe culvert type emergency spillway was installed replacing an earth type section. According to the Owner, the improvements were done by the Hensley Contruction Company, of Imperial, Missouri. The Owner also stated that in 1976, a representative of a State agency visited the site and provided advice regarding construction of the dam; however, the name of the individual or the agency could not be recalled.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the combined capacities of a 12-inch diameter pipe principal spillway and a 30-inch diameter pipe emergency spillway.

1.3 PERTINENT DATA

a. Drainage Area. Except for a man-made lake of about 1.8 acres and two small ponds of less than one-half acre each, the area tributary to the lake is almost entirely tree covered. An unimproved roadway traverses the ridgeline of the watershed. The watershed above the dam amounts to approximately 61 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 2 cfs* (W.S. Elev. 605.5)
(2) Spillway capacity (principal + emergency) ... 46 cfs (W.S. Elev. 612.6)

c. Elevation (Ft. above MSL). Unless otherwise indicated, the following elevations were determined by survey and are based on topographic data shown on the 1954 Herculaneum, Missouri, Quadrangle Map, 7.5 Minute Series, photorevised 1968 and 1974.

*Based on an estimate of maximum depth of flow at spillway as reported by Owner.

(1) Observed pool ... 605.1

(2) Normal pool ... 605.0

(3) Spillway crest

a. Principal ... 605.0

b. Emergency ... 609.0

(4) Maximum experienced pool ... 605.5 (per Owner)

(5) Top of dam ... 612.6 (Min.)

(6) Streambed at centerline of dam ... 580± (Est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 605.0) ... 700 ft.

(2) Length at maximum pool (Elev. 612.6) ... 750 ft.

e. Storage.

(1) Normal pool ... 26 ac. ft.

(2) Top of dam ... 56 ac. ft.

f. Reservoir Surface Area.

(1) Normal pool ... 3.4 acres.

(2) Top of dam ... 4.6 acres

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier to the top of the dam.

(1) Type ... Earthfill

(2) Length ... 460 ft.

(3) Height ... 38 ft.

(4) Top width ... 20 ft.

(5) Side slopes

a. Upstream ... lv on 1.3h (Max., above waterline)

b. Downstream ... Irregular, lv on 1.2h (Max.)

(6) Cutoff ... Core trench*

(7) Slope protection

a. Upstream ... Grass

b. Downstream ... Grass (very sparse)

h. Principal Spillway.

(1) Type ... Uncontrolled, 12-inch diameter asbestos-cement pipe culvert

(2) Location ... Left end of dam

(3) Crest elevation ... 605.0

(4) Approach channel ... Lake

(5) Outlet channel ... Excavated earth, irregular section

i. Emergency Spillway.

(1) Type ... Uncontrolled, 30-inch corrugated metal pipe culvert

(2) Location ... Left end of dam

(3) Crest elevation ... 609.0

(4) Approach channel ... Lake

(5) Outlet channel ... Common with principal spillway

j. Lake Drawdown Facility. ... None

*Per Owner.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Data relating to the design of the dam were unavailable.

2.2 CONSTRUCTION

As previously stated, the dam was originally constructed in 1976 by the J. H. Berra Construction Company of St. Louis, Missouri. Records of the construction activities were unavailable. According to Mr. Frank Berra of the J. H. Berra Construction Company, equipment consisting of a high-lift and a bulldozer along with an operator, were leased to Mr. Francois. However, the equipment operator was directed by Mr. Francois during construction of the dam. According to Mr. Francois, a seepage cutoff core trench approximately 20 feet wide at the bottom and about 8 feet in depth, was excavated to solid clay along the centerline of the dam. Mr. Francois also reported that the dam was constructed with a crest width on the order of 10-to-12 feet, an upstream slope of 1v on 3.0h, a downstream slope of 1v on 3.5h, and that compaction of the embankment fill was achieved by running the equipment over the earth fill material. At the time the original dam was constructed, the 12-inch diameter pipe was intended to be temporary and an excavated earth type emergency spillway was provided. The Owner also reported that an 8-inch diameter pipe approximately 30 feet in length was installed beneath the dam for the purpose of draining the lake; however, the pipe was filled with concrete when the dam was about 10 feet high and the drain pipe was abandoned.

In 1979, the dam was raised approximately 5 feet and the crest was widened to about 20 feet. According to Mr. Francois, the work was done by the Hensley Construction Company of Imperial, Missouri. Mr. Francois reported that a second seepage cutoff core trench was constructed at the location of the toe of the original dam, and that the proportions of the core were about the same as those of the original core constructed in 1976. A small slide that had cut about 3 feet into the crest of the original dam was also repaired at this time. The Owner reported that the slopes of the upstream and downstream sides of the dam were intended to be the same as the original dam, i.e., 1v on 3.0h upstream and 1v on 3.5h downstream, but that construction is incomplete and some additional work remains in order to achieve the downstream slope. Mr. Francois also reported that compaction of the new embankment fill material was obtained using a sheepsfoot roller and by running the earth hauling vehicles, Euclid trucks, over 6 inch thick layers of earth fill. The Owner indicated that compaction tests were made, but that records of these tests have been misplaced. In addition, the excavated earth spillway was replaced with a 30-inch diameter pipe in order for equipment to access the area north of the dam. Fill material about the pipe was compacted by hand and concrete slope protection was provided at the upstream ends of both spillway pipes.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of a 12-inch diameter pipe, culvert type, spillway. A 30-inch diameter pipe, culvert type, emergency spillway also provides an outlet for lake surcharge. The crest of the 30-inch pipe spillway is approximately 4.0 feet higher than the crest of the 12-inch pipe spillway, and about 3.6 feet lower than the top of the dam at its lowest point. There is no functional lake drawdown facility. No indication was found that the dam has been overtopped. Mr. David Francois, the Owner, reported that the dam has never been overtopped. The highest lake level observed by Mr. Francois, occurred about two and one-half years ago when a storm produced a depth of flow at the 12-inch pipe spillway estimated to be on the order of 6 inches.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Francois Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, H. B. Lockett, Hydrologist, and A. B. Becker, Jr., Civil and Soils Engineer, on 6 November 1980. The Owner was not present during this inspection. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on pages A-1 through A-4 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The Francois Lake Dam is located on an unnamed stream which flows into the Mississippi River located approximately 3 miles to the east. The topography of the drainage basin is moderately rugged, and there is about 250 feet of relief between the reservoir and the adjacent uplands. The area is included within the northeastern part of the Ozark Plateaus Physiographic Province, and regionally, the bedrock structure dips northeastward into the Illinois Basin.

The bedrock at the site consists of the Ordovician-age Kimmswick formation. The uplands surrounding the reservoir are underlain by several Ordovician- and Mississippian-age formations, principally the limestones of the Burlington formation which underlies most of the area and which has provided the residuum for much of the soil cover.

The Kimmswick is a coarsely crystalline, light gray, massive- to medium-bedded limestone. It has a distinctive pitted, weathered surface, and nodular chert is scattered in the upper portion of the formation. The Kimmswick has typically been extensively solution-weathered and commonly contains numerous sinks and solution-enlarged fractures. This weathering has made the limestone very permeable, and it will transmit water readily. The contact between the weathered bedrock surface and the overlying residuum is usually very irregular. The residual soils, when not modified by colluvium, are quite thin and typically a reddish-brown, well-structured plastic clay (CH, Unified Soil Classification System).

The Burlington formation is also a light gray, massively- to medium-bedded limestone; however, it is characterized by having considerable amounts of nodular and bedded chert. The residual soils are light red to reddish-brown clays mixed with chert (stone CL to CH). In general, the residuum from the Burlington is the major component of the soils comprising the uplands.

At the reservoir, the soils are reddish brown, silty, slightly plastic and contain a high chert content (cherty ML-CL). On steep slopes, where the vegetation and surface layers have been stripped for dam construction, the soils have been subjected to intensive erosive activity, and extensive gullying has occurred. In addition, the downstream face of the dam also has been subjected to extensive erosion, and as a result, there has been a significant deposition of sediment across the valley floor downstream from the dam. Some small soil slumps were also noted on the right side of the reservoir, coincidental with seepage along the bedrock-soil contact.

Although no seepage was noted at the toe of the dam or in the valley walls downstream from the dam, the presence of several springs within the drainage basin suggests that water from the reservoir may be seeping into the permeable bedrock.

The most significant geologic conditions at the site are the erodibility of the soils on bare slopes and the apparent permeability of the solution-weathered bedrock.

c. Dam. The visible portions of the upstream and downstream faces of the dam, as well as the dam crest (see Photos 1, 2 and 3), were examined and found, except where damaged by erosion, to be in sound condition. Erosion, that appeared to be a result of wave action or fluctuations of the lake level, had created a near vertical bank approximately 12 inches high at the normal waterline across most of the unprotected (no riprap) upstream face of the dam. Extensive erosion, apparently by overland drainage, had created numerous V-shaped gullies 18-to-24 inches deep (see Photo 10) and several V-shaped gullies up to 48 inches in depth (see Photo 11) across the entire downstream face of the dam. Although a fairly thick stand of grass (fescue) and weeds up to about 3 feet in height, covered the upstream face of the dam, the turf cover on the crest and downstream face was exceptionally sparse, particularly along the center of the crest which apparently has been used as a roadway to access the area north of the dam, and across the lower two-thirds (see Photo 3) of the dam. Several erosion gullies up to 10 inches deep were also observed at the right abutment in the area just upstream of the dam and along the roadway (see Photo 12) that leads to the dam. Examination of a soil sample obtained from the downstream face of the embankment near the center of the dam indicated the surficial material to be a yellow, silty-clay (ML-CL) of low-to-medium plasticity.

The upstream and downstream ends of the 12-inch diameter asbestos-cement pipe spillway (see Photos 4 and 5) and the 30-inch corrugated metal pipe spillway (see Photos 6 and 7) were examined and found to be in sound condition, although the 30-inch pipe section appeared to have a 4-to-6-inch sag in the top at a point about 20 feet from the downstream end of the outlet. It could not be determined if soil was entering the pipe at the location of the sag; however, some earth was observed within the pipe at the downstream end. The concrete slope protection about the upstream ends of each pipe was examined and several cracks were noted at each section. It was not evident if the cracks were due to shrinkage of the concrete or to settlement of the subgrade. Cracks up to 1 inch in width were observed. The spillway outlet channel was also inspected and found to be in less than satisfactory condition, primarily due to the fact that the bank on the right side which serves to confine flow to the channel, varied from a section about 2 feet high at the dam to almost nothing at a point about 50 feet away from the dam. At this point, it appeared that flow had left the channel and followed a course down the hillside to the original stream channel below the dam. For the most part, the invert and bank on the right side of the channel had only a sparse, vegetative type cover to prevent erosion by lake outflow. In the vicinity of the dam, the left side of the channel was protected by rock outcroppings exposed by excavation of the hillside for the channel.

A field survey of the dam upstream of the Francois Lake Dam was also made for the purpose of determining the proportions of the upstream dam and spillways. As previously indicated, the results of this survey are presented on Plate 5. An overview photograph (see Photo 8) of the upper dam and a view of Francois Lake including the small pond just downstream of the upper dam (see Photo 9) are presented on page A-3 of Appendix A.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site.

e. Downstream Channel. Except at roadway crossings, the channel downstream of the dam within the potential flood damage zone is unimproved. The channel section is irregular and for the most part, lined with trees, although portions of the flood plain just west and east of Interstate Highway 55 are farmed and cultivation of these areas extends to near the stream bank. The tributary joins the Mississippi River at a point about 3 miles downstream of the dam.

f. Reservoir. Except for an area approximately 300 feet long just upstream of the right abutment which appears to have been used as a source of borrow for construction of the dam and a similar area about one-half as long at the left abutment, the area adjacent to the lake is tree covered. Excavation of material from the borrow area just upstream of the right abutment has steepened the hillside south of the reservoir considerably. For the most part, these hillside areas are turf covered to prevent erosion; however, numerous erosion rills along with several gullies up to 10 inches in depth were observed in the area near the right abutment. Transportation of soil, apparently by stormwater runoff has created several delta-like areas with deposits of sediment extending into the lake along the shoreline beginning at the dam and extending upstream for approximately 300 feet, the largest of these sediment areas being about 15 feet wide and 25 feet long which, at the time of the inspection, extended into the reservoir approximately 5 feet. No other areas of sedimentation were noted. Although, as indicated herein, some sediment within the lake was noted during the inspection, the amount is not considered sufficient to significantly reduce the storage capacity of the reservoir.

3.2 EVALUATION

Examination of the area in the vicinity of the right abutment indicated that a considerable amount of stormwater runoff is being channeled along the road that leads to the dam. The overland drainage that follows the road follows a course that directs the runoff along the crest of the dam, where at about stations 2+70 and 3+05, the drainage is directed down the downstream face of the dam. It is at these locations, stations 2+70 and 3+05, that extensive erosion of the embankment, as illustrated by Photos 10 and 11, has occurred and, according to survey data obtained during the inspection, the slope of the downstream face of the dam was found to be as steep as 1v on 1.2h at the location of the surveyed cross-section. A slope of 1v on 1.2h is considered to be excessively steep. No undue settlement of the dam or obvious sloughing of the embankment slopes was noticed; however, due to the eroded condition of the downstream face as well as the irregularity of the slope (see dam cross-section on Plate 4), it is evident that the downstream side of the dam needs considerable attention within the very near future. In addition, measures should be taken to direct overland drainage away from the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillways are uncontrolled. The lake surface is governed by precipitation runoff, evaporation, seepage, and the combined capacities of two uncontrolled pipe culvert spillways.

4.2 MAINTENANCE OF DAM

According to the Owner, the dam is still under construction (the dam was raised approximately 5 feet in 1979) and some additional work, such as finishing the downstream side of the embankment, surfacing the dam crest and the provision of a drainage system to prevent stormwater runoff from eroding the dam, remains to be done and consequently, no routine maintenance of the dam has been performed since 1979.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Although it was indicated that the dam is scheduled for completion sometime in the near future, the downstream face of the dam is extensively eroded and restoration of the downstream side should not be delayed. To this end, the hillside drainage should be intercepted and provisions made to prevent further erosion of the dam by stormwater runoff. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were not available.

b. Experience Data.

(1) The drainage area and lake surface area were developed from the 1954 USGS Herculaneum, Missouri, Quadrangle Map (photorevised 1968 and 1974). The proportions and dimensions of the spillways and dam, including the upper reservoir dam, were developed from surveys made during the inspection. Records of rainfall, streamflow or flood data for the watershed are not available.

(2) The level of the upper lake prior to the beginning of the one percent chance flood and the PMF antecedent storms was considered to be the assumed annual high water level, elevation 644.0, with storage equivalent to 7.9 acre-feet. This elevation was established during the inspection and is based upon a waterline mark on the upstream face of the dam. Due to the fact that the watershed for the Francois Lake reservoir is small and since there is no history of excessive reservoir leakage that would adversely affect the normal operating level of the lake, the lake level was assumed to be at normal pool, elevation 605.0, as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

(3) For the upper lake, in accordance with criteria established by the St. Louis District, Corps of Engineers, for the one percent chance (100-year frequency) storm, the 24-hour runoff from the rainfall distribution for the 24 hours preceding the maximum 24 hours was evaluated and found to be 0.40 inch, and the computed volume of runoff for the antecedent storm amounted to 1.11 acre-feet, resulting in accumulated storage equal to 9.01 acre-feet at elevation 644.83 at the beginning of the one percent chance (100-year frequency) storm. For the PMF ratio events, the upper lake reservoir was assumed to be at normal pool level, elevation 648.5, prior to the occurrence of these flood events. It was determined that the antecedent storms for the PMF ratio events considered (0.19, 0.50, and 1.0) would result in the lake

surface of the upper reservoir rising above the spillway crest. It was assumed that the lake level would then recede to the elevation of the spillway crest prior to the occurrence of the PMF ratio storms.

(4) According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends three miles downstream of the dam.

c. Visual Observations.

(1) The principal spillway, a 12-inch diameter pipe culvert, is located near the left, or north, end of the dam. The emergency spillway, a 30-inch diameter pipe culvert, is also located at the left end of the dam. A common outlet channel serves both pipe spillways. The outlet channel joins the original stream channel at a point approximately 150 feet downstream of the toe of the dam.

(2) A second dam impounding a lake of approximately 1.8 acres at spillway crest elevation is located approximately 950 feet upstream of the Francois Lake Dam. This dam has an excavated earth type spillway which is located at the right abutment.

(3) Ditches, located at the abutments opposite the ends of the upper lake dam, intercept hillside runoff and carry this drainage to the downstream Francois Lake.

(4) The two small ponds located upstream of Francois Lake were considered to be hydrologically insignificant so far as the analyses of overtopping contained herein are concerned.

d. Overtopping Potential. Since it was found that the spillway capacity of the upper lake dam was less than 50 percent of the PMF inflow (the actual capacity was determined to correspond to approximately 15 percent of the PMF inflow), and in accordance with criteria prescribed by the St. Louis District, Corps of Engineers, the upstream dam was assumed to breach, after overtopping, during occurrence of the PMF ratio storms. For the one percent chance storm, the upper lake was found to reach a maximum level of 0.1 foot below the dam crest.

The spillways (principal plus emergency) of the Francois Lake Dam are inadequate to pass the probable maximum flood or one-half the probable maximum flood without overtopping the dam. The spillways are adequate, however, to pass the 1 percent chance (100-year frequency) flood without overtopping the dam. The results of the dam overtopping analysis are as follows:

(Note: The data appearing in the following table has been extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max. Lake W.S. Elev.	Max. Depth (Ft.) of Flow Over Top of Dam (Elev. 612.6)	Duration of Overtopping of Dam (Hrs.)
0.50	604	614.1	1.5	6.2
1.00	1,350	614.6	2.0	8.0
1% Prob.Flood	6	607.9	0.0	0.0

Elevation 612.6 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping amounts to approximately 46 cfs, which is the routed outflow (including the outflow from the upper lake) corresponding to about 19 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 2.0 feet, and overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty clay of low-to-medium plasticity) to that used to construct this dam have shown evidence that the material, under certain conditions such as high velocity flow, can be very erodible. Such a condition exists during the PMF (the recommended spillway design flood) when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition, where the depth of flow over the dam crest, a maximum of 2.0 feet, and the duration of flow over the dam, 8.0 hours, are considerable, extensive damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable within the scope of these investigations; however, there is a definite possibility that they could result in failure by erosion of the dam.

f. Reference. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillways and dam crest are presented on pages B-1 through B-3 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on pages B-4 through B-7. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-8 through B-11; tabulations of lake surface area, elevation and storage volume are shown on page B-12 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are shown on pages B-13 and B-14.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam. According to the Owner, records of the lake level, spillway discharge, dam settlement, or lake seepage have not been kept.

d. Post Construction Changes. As previously indicated, in 1979, the dam was raised approximately 5 feet, the dam crest was widened to about 20 feet, and the excavated earth emergency spillway was replaced with a pipe culvert type spillway. According to the Owner, with the exception of the 1979 additions to the original dam, no other post construction changes have been made or have occurred which would affect the strucutral stability of the dam. A possible exception would be the rather extensive erosion of the downstream face of the dam that has occurred since completion of the 1979 improvements.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the spillways are capable of passing lake outflow of about 46 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of probable maximum flood magnitude, the lake outflow would be about 1,350 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 6 cfs. Since the existing spillways are inadequate to pass lake outflow resulting from a storm of PMF magnitude (the recommended spillway design flood for this dam) without overtopping the dam, the possibility exists that overtopping could result in failure by erosion of the dam during this flood event. A description of the features within the potential flood damage zone should failure of the dam occur is presented in Section 1, paragraph 1.2d.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include extensive erosion of the downstream face of the dam, erosion of the upstream face of the dam and right abutment area, tall grass and weeds along the upstream face of the dam and the lack of a durable form of erosion protection, such as riprap, across the upstream face, as well as the lack of turf cover on the dam crest, downstream face, and right abutment in order to prevent erosion by overland drainage.

b. Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacities of the spillways were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished within the near future. The item concerning increasing spillway capacity should be pursued on a high priority basis.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located within a Zone II seismic probability area. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earthen dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended.

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude, the recommended spillway design flood for this dam. In either case, the spillway including the spillway outlet channel should be protected to prevent erosion.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The inspection team is aware of the fact that the dam, according to the Owner, is incomplete and some additional work remains to be done, and that this work is scheduled for sometime in the near future. Nevertheless, certain remedial measures should be taken as soon as practical to insure the safety of the structure. To this end, the following measures are recommended:

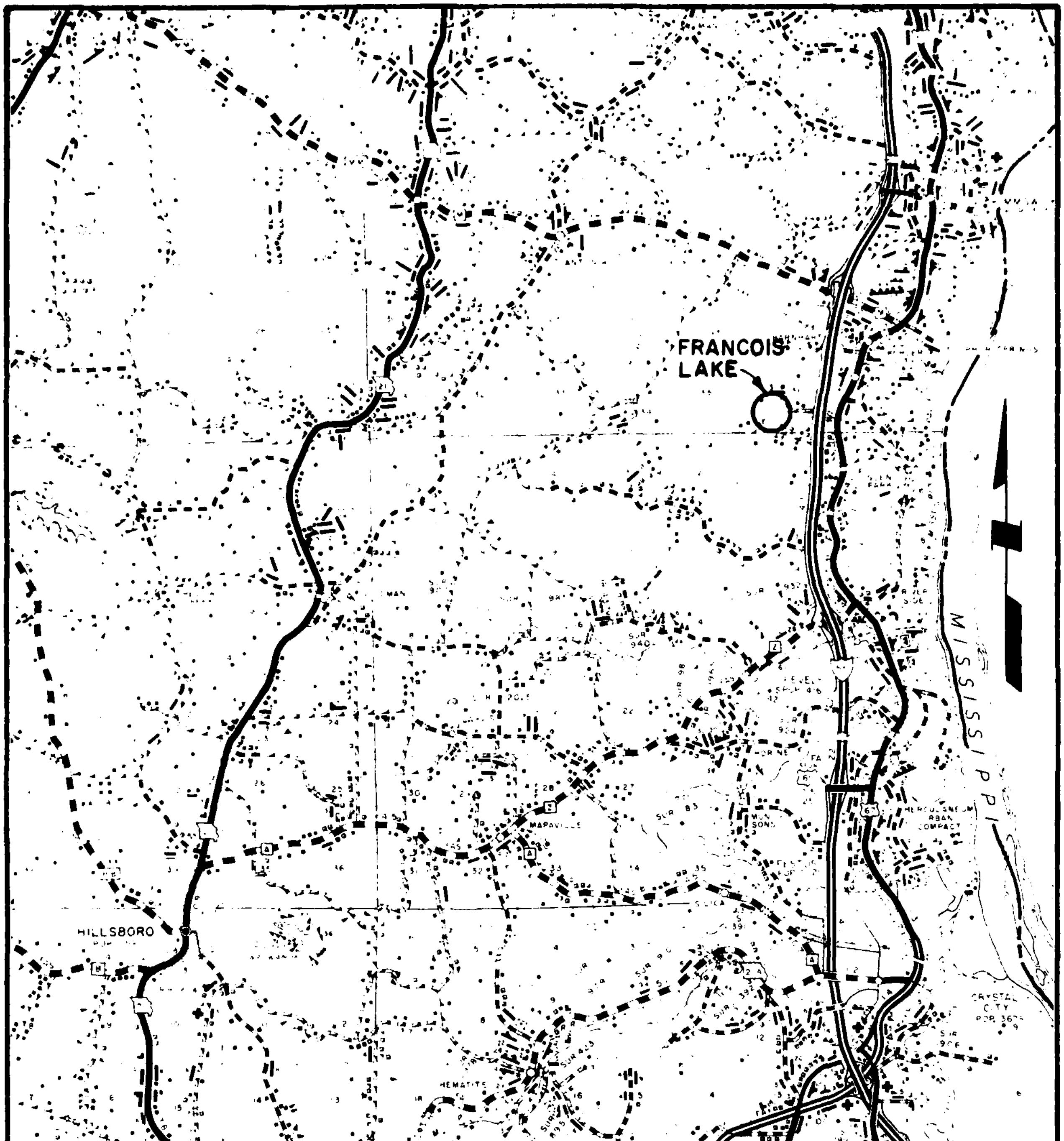
(1) Restore the eroded areas of the dam and provide some form of cover in order to prevent erosion of the embankment by overland drainage. Loss of embankment material due to erosion can impair the structural stability of the dam. In any event, the drainage from the area in the vicinity of the right abutment should be controlled and/or prevented from flowing across the dam and down the downstream face of the embankment.

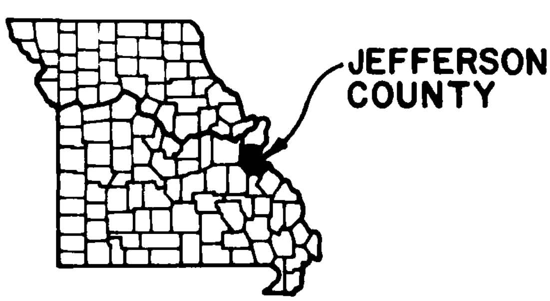
(2) Provide some form of protection other than grass for the upstream face of the dam at and above the normal waterline in order to prevent erosion by wave action or by a fluctuating lake level. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by fluctuations of the lake level. As indicated above, loss of embankment material due to erosion can impair the structural stability of the dam.

(3) Maintain the turf cover on the dam at a height that will not provide cover for burrowing animals or hinder inspection of the dam. Animal burrows can provide passageways for lake seepage that can develop into a piping (progressive internal erosion) condition that could lead to failure of the dam.

(4) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

(5) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.





LOCATION MAP

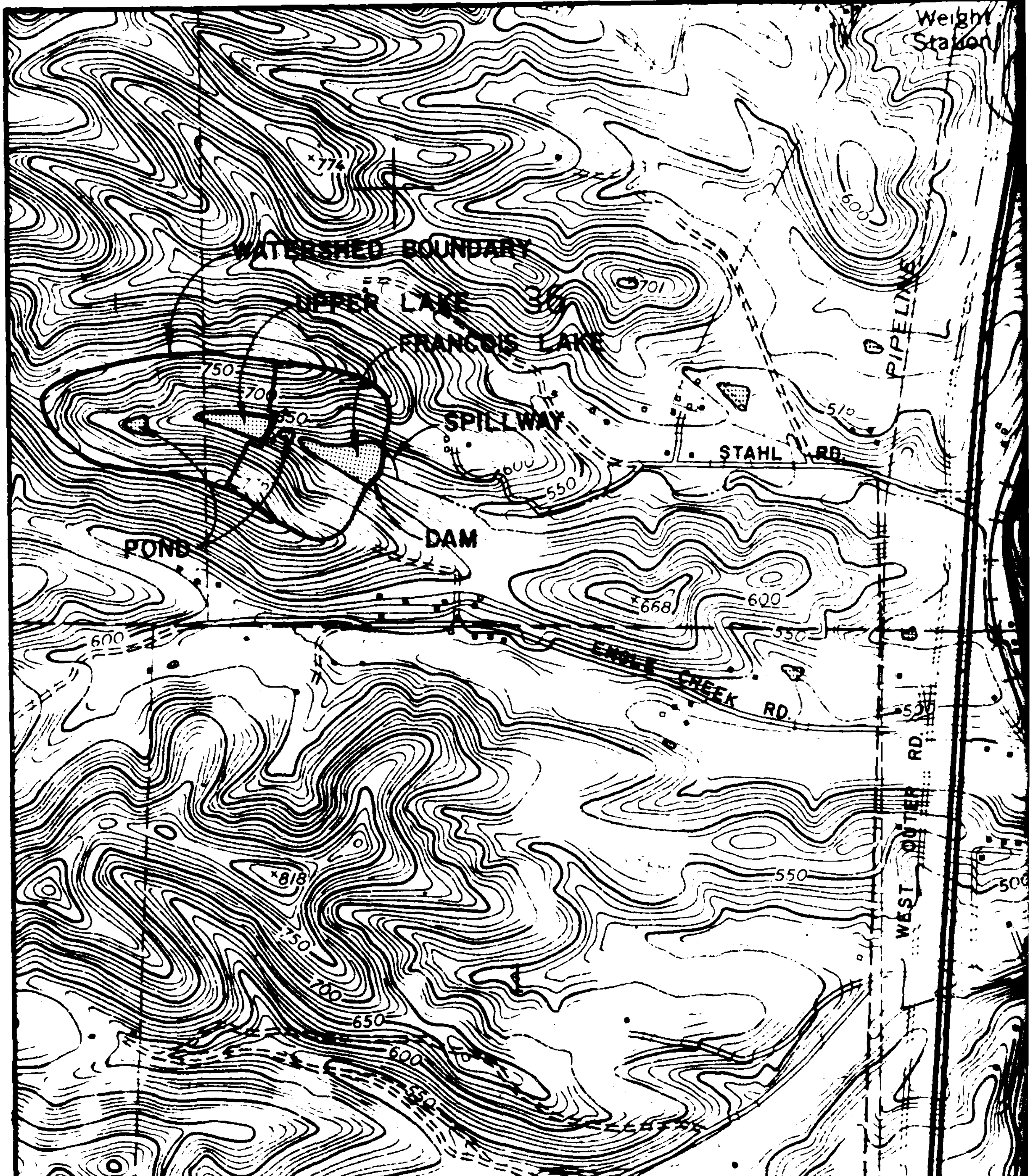
FRANCOIS LAKE

1 0 1 2 3 4

SCALE (MILES)

REGIONAL VICINITY MAP

PLATE I


WATERSHED BOUNDARY
UPPER LAKE
36
FRANCOIS LAKE
SPILLWAY
POND
DAM
STAHL RD.
EAGLE CREEK RD.
WEST OUTER RD.
PIPELINE
Weight Station
Sun Valley Park
APPROXIMATE EXTENT OF DOWNSTREAM DAMAGE ZONE

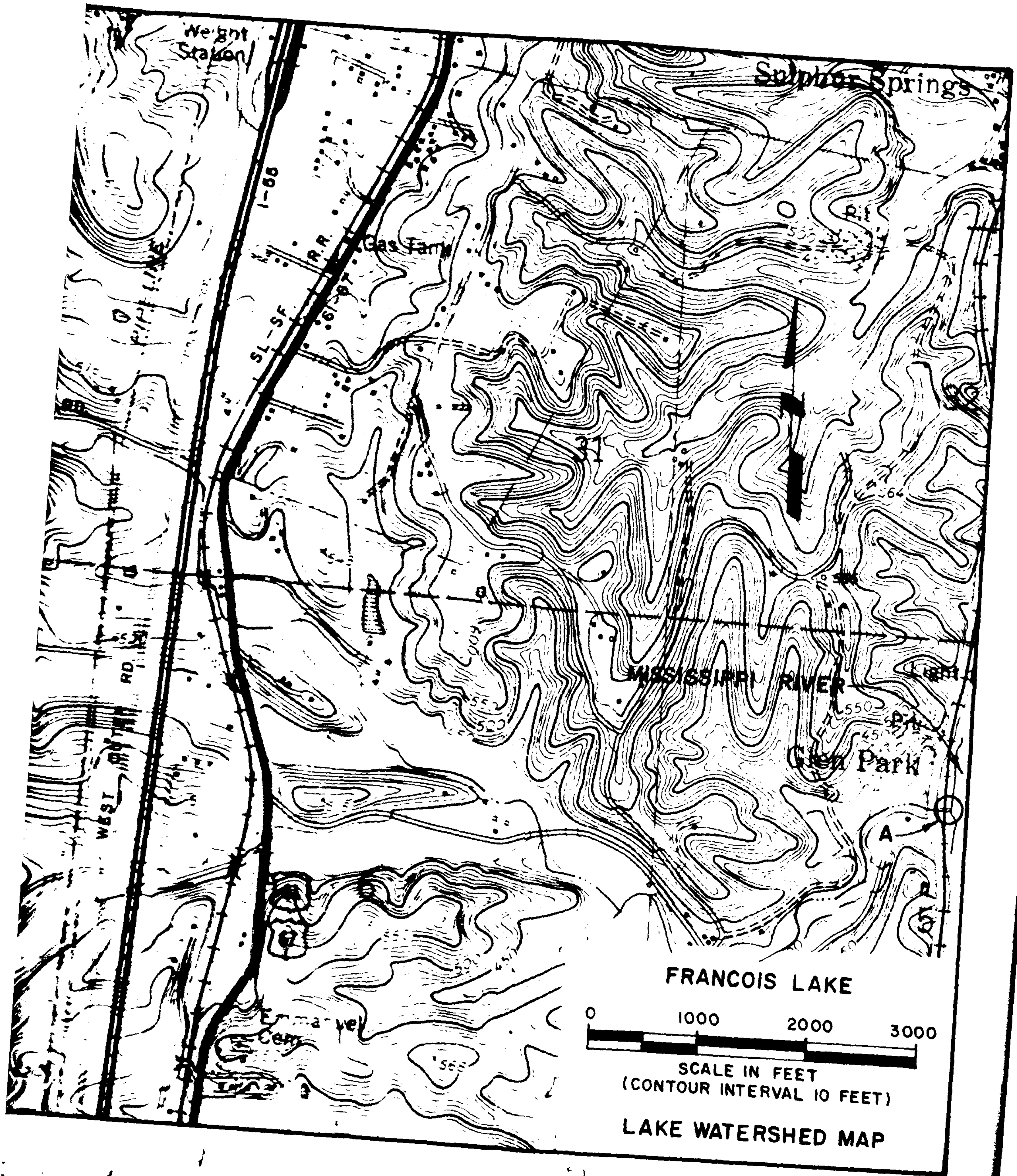
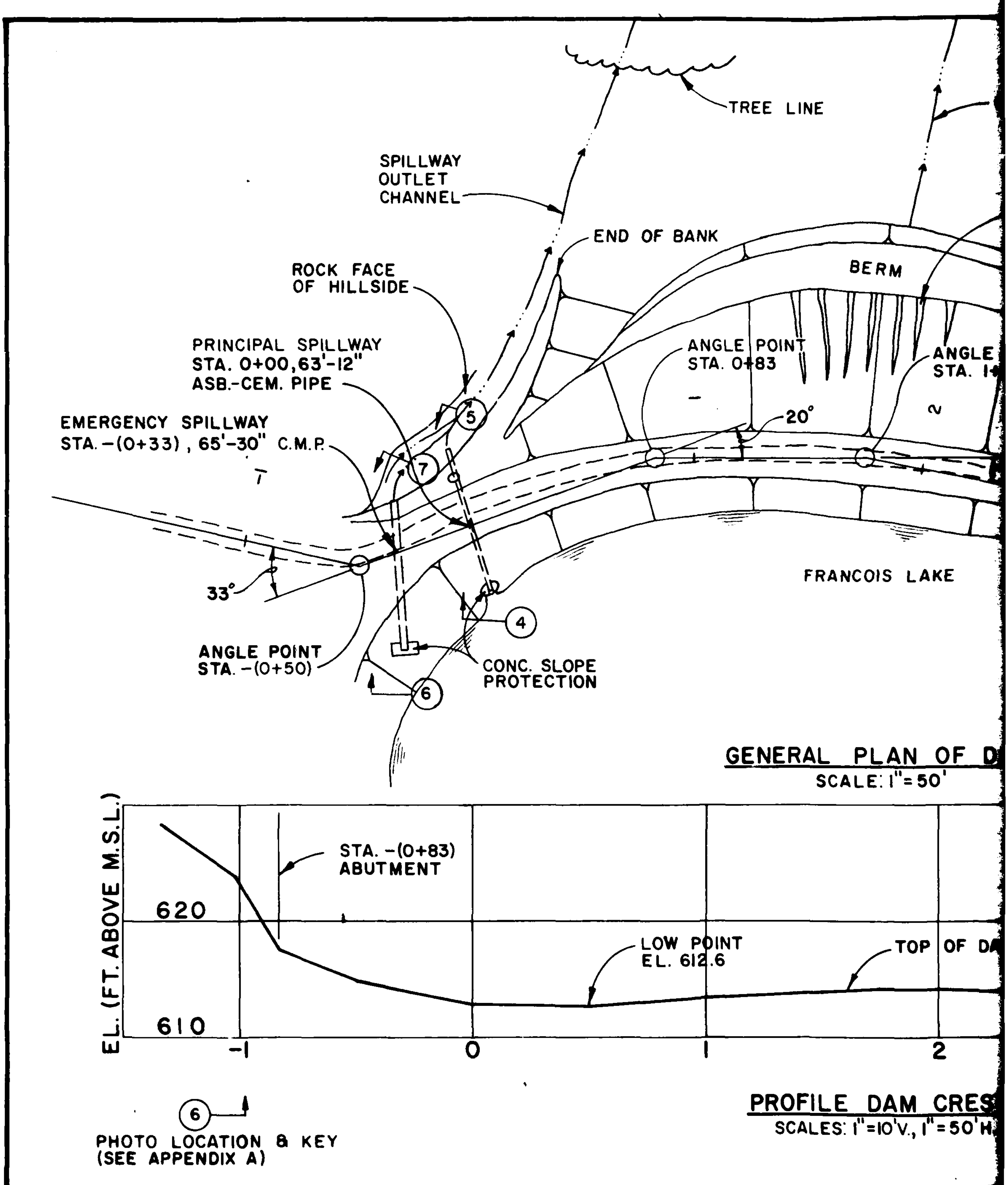
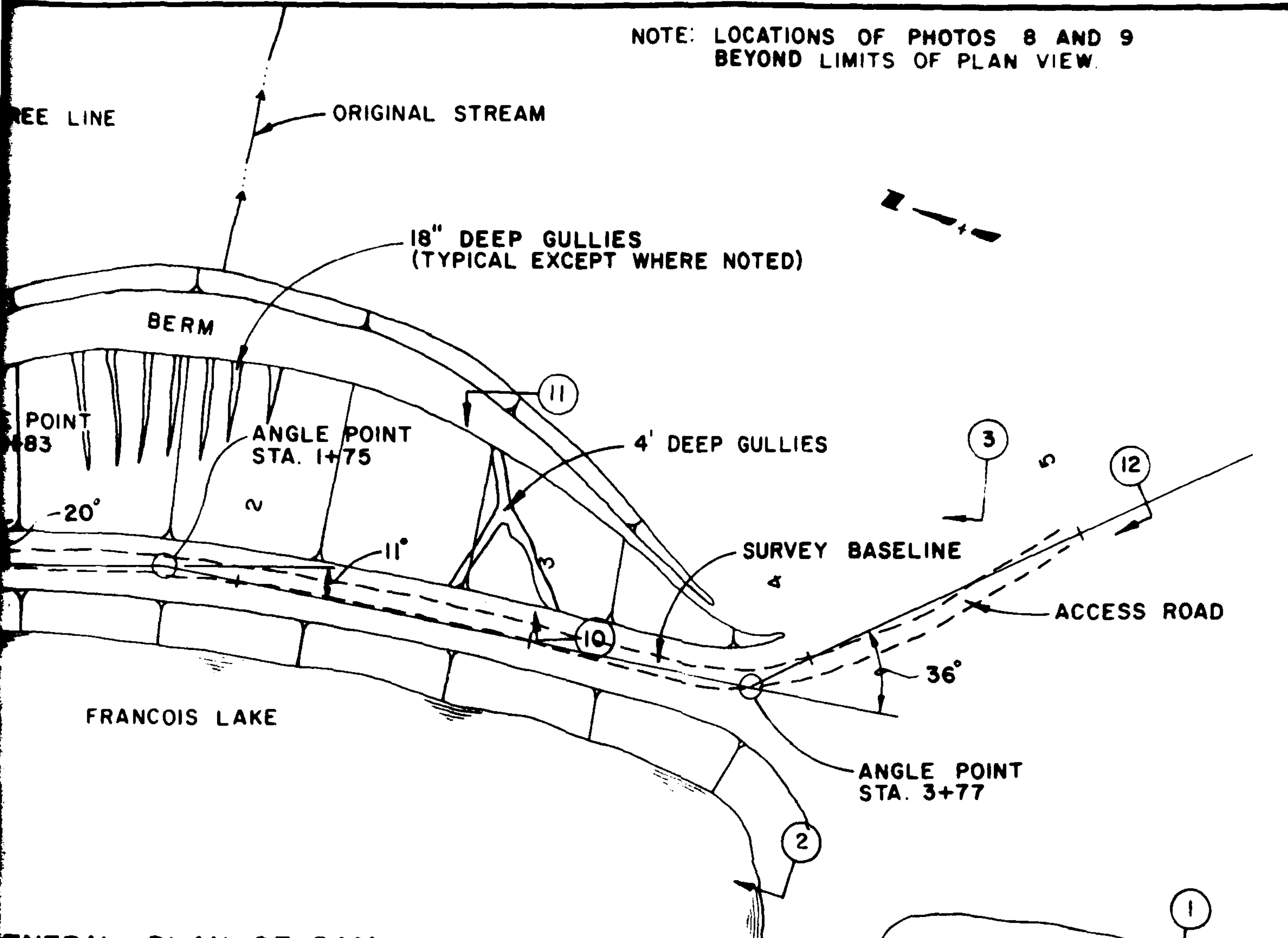

Weight Station
Sulphur Springs
I-55
Gas Tank
SL-SF R.R.
WEST RD.
MISSISSIPPI RIVER
Glen Park
A
Emmanuel Cem
FRANCOIS LAKE
0
1000
2000
3000
SCALE IN FEET
(CONTOUR INTERVAL 10 FEET)
LAKE WATERSHED MAP

PLATE 2

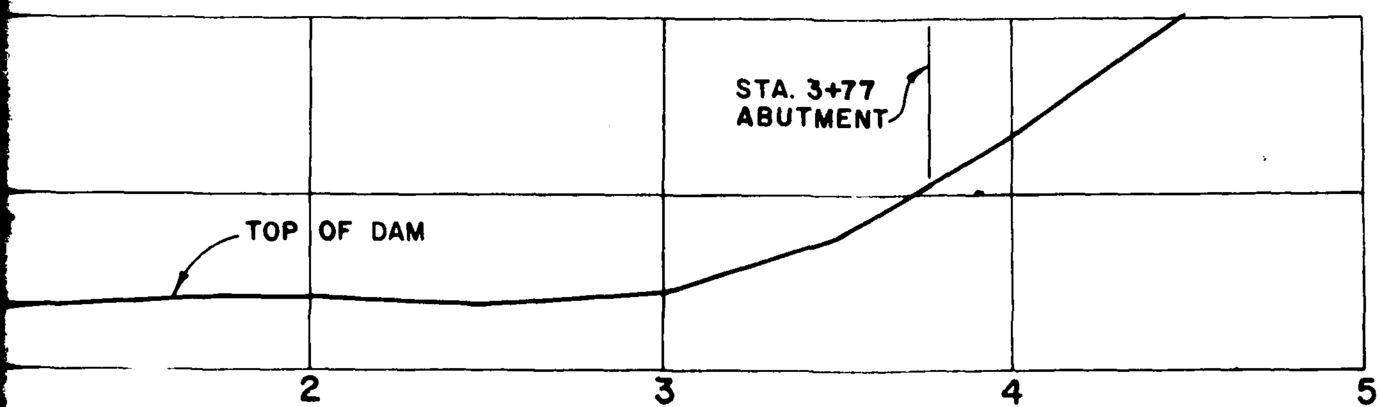


TREE LINE
SPILLWAY
OUTLET
CHANNEL
END OF BANK
BERM
ROCK FACE
OF HILLSIDE
PRINCIPAL SPILLWAY
STA. 0+00, 63'-12"
ASB.-CEM. PIPE
ANGLE POINT
STA. 0+83
ANGLE
STA. 1+
20°
EMERGENCY SPILLWAY
STA. -(0+33), 65'-30" C.M.P.
33°
FRANCOIS LAKE
ANGLE POINT
STA. -(0+50)
CONC. SLOPE
PROTECTION
5
7
4
6
GENERAL PLAN OF D
SCALE: 1"=50'
EL. (FT. ABOVE M.S.L.)
STA. -(0+83)
ABUTMENT
620
610
LOW POINT
EL. 612.6
TOP OF DA
-1
0
1
2
PROFILE DAM CRES
SCALES: 1"=10'V., 1"=50'H.
6
PHOTO LOCATION & KEY
(SEE APPENDIX A)



ENERAL PLAN OF DAM

SCALE: 1"=50'



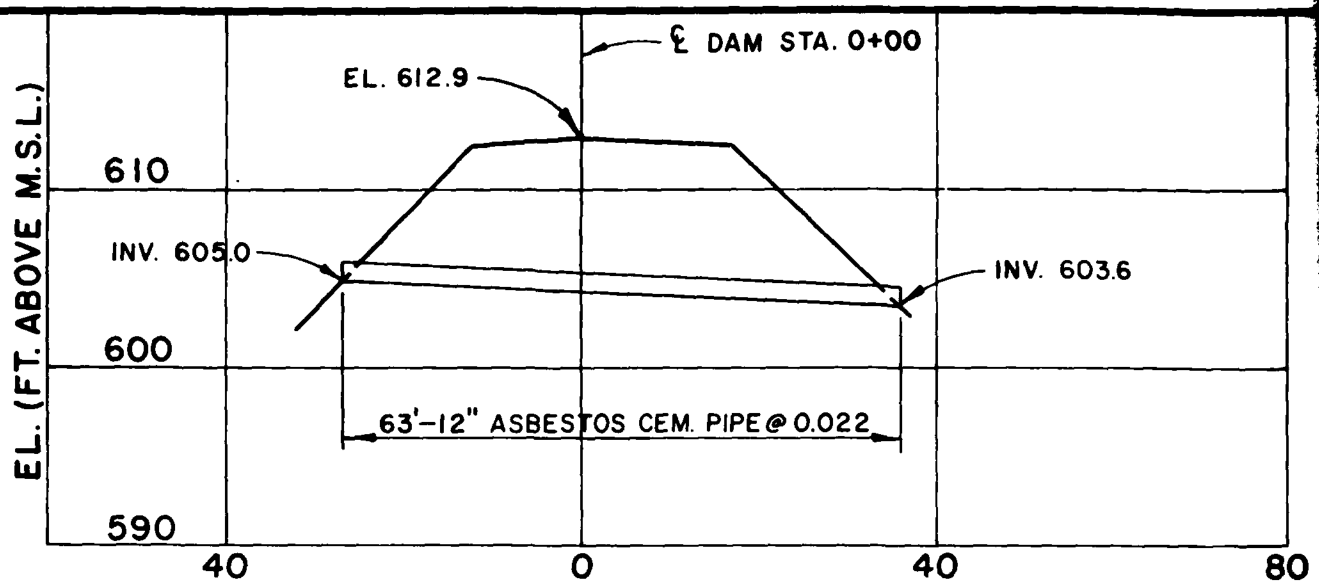
PROFILE DAM CREST

SCALES: 1"=10'V., 1"=50'H.

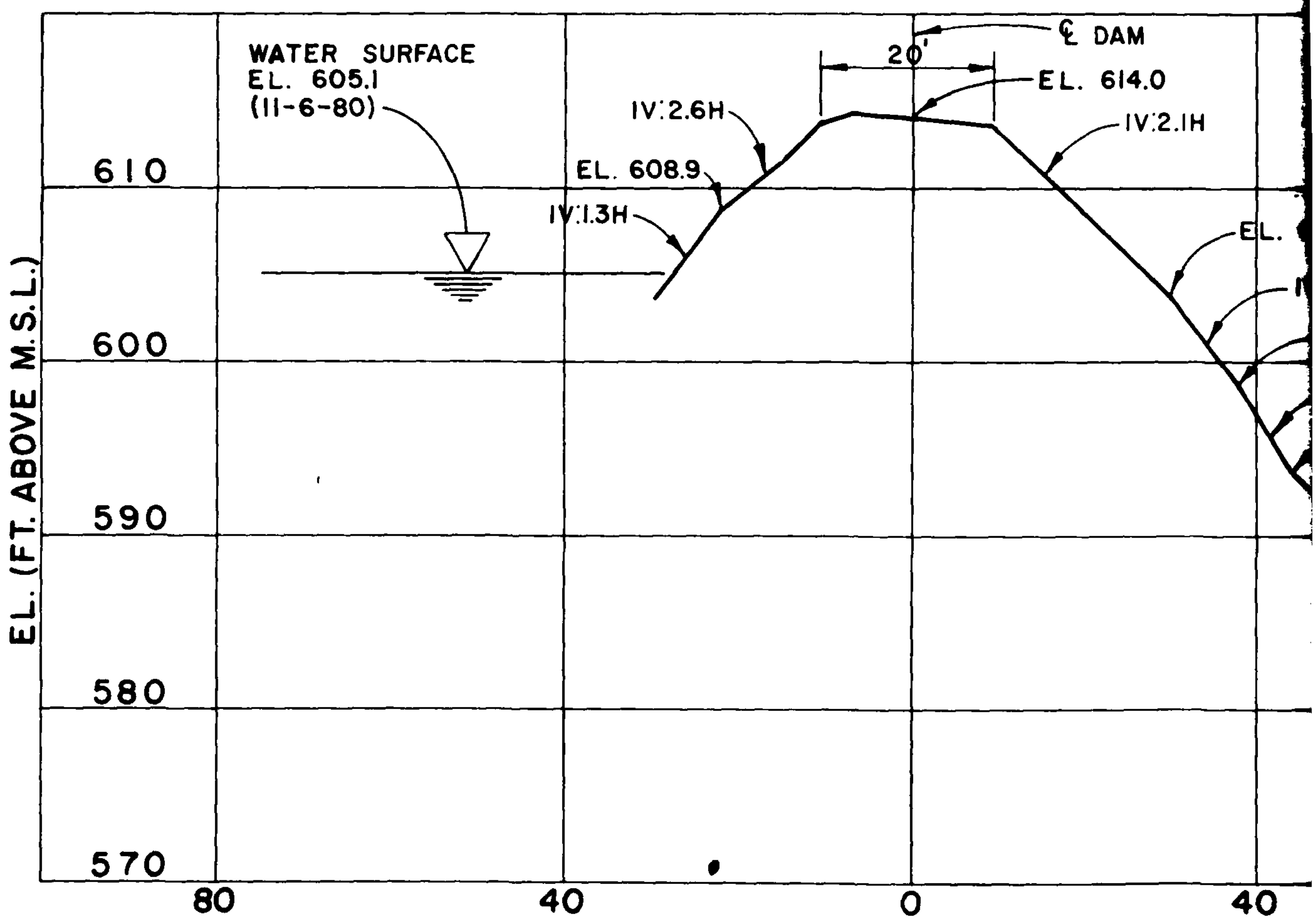
FRANCOIS LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. Jan. 1981

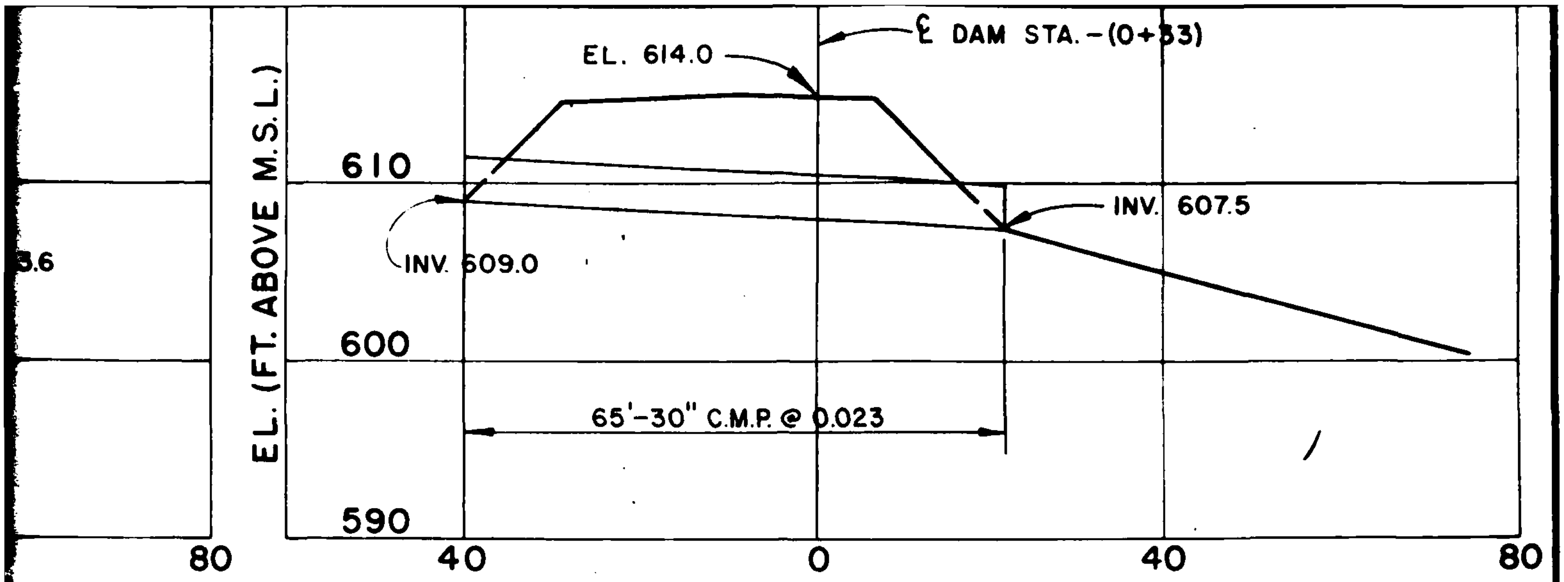
PLATE 3



PROFILE PRINCIPAL SPILLWAY
SCALES: 1"=10' V., 1"=20' H.

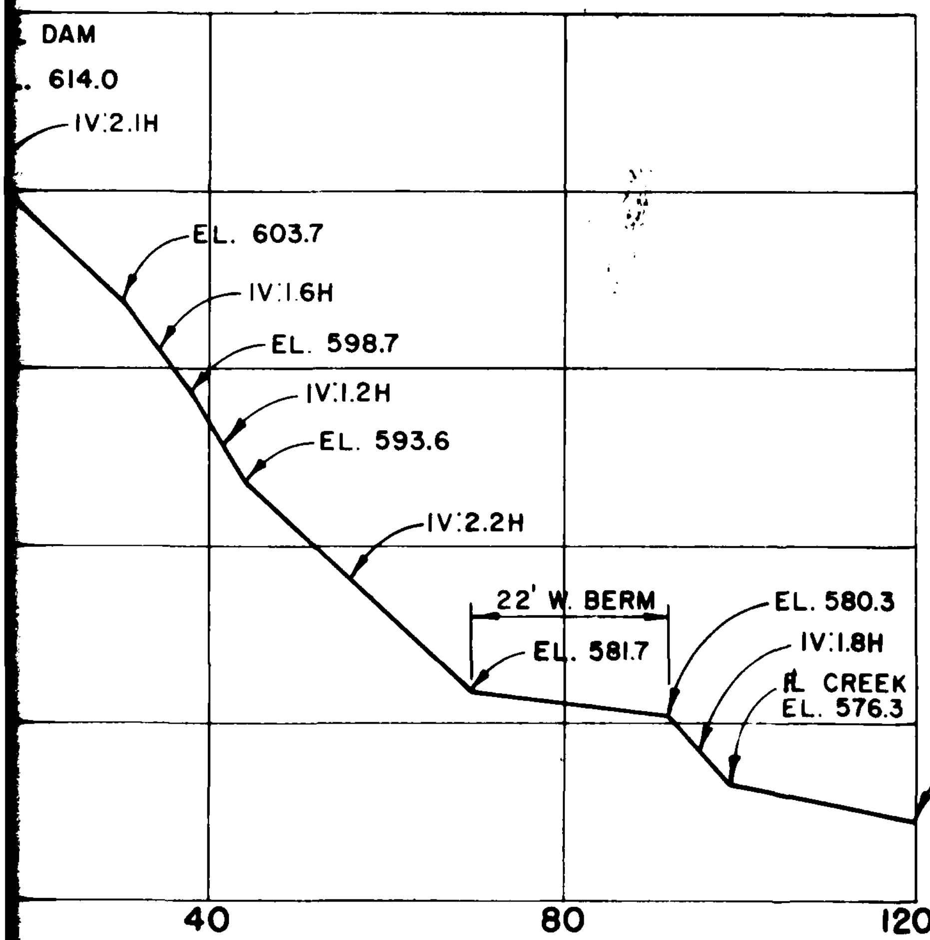


FRANCOIS DAM CROSS-SECTION
SCALES: 1"=10' V., 1"=20' H.



PROFILE EMERGENCY SPILLWAY

SCALES: 1"=10' V., 1"=20' H.

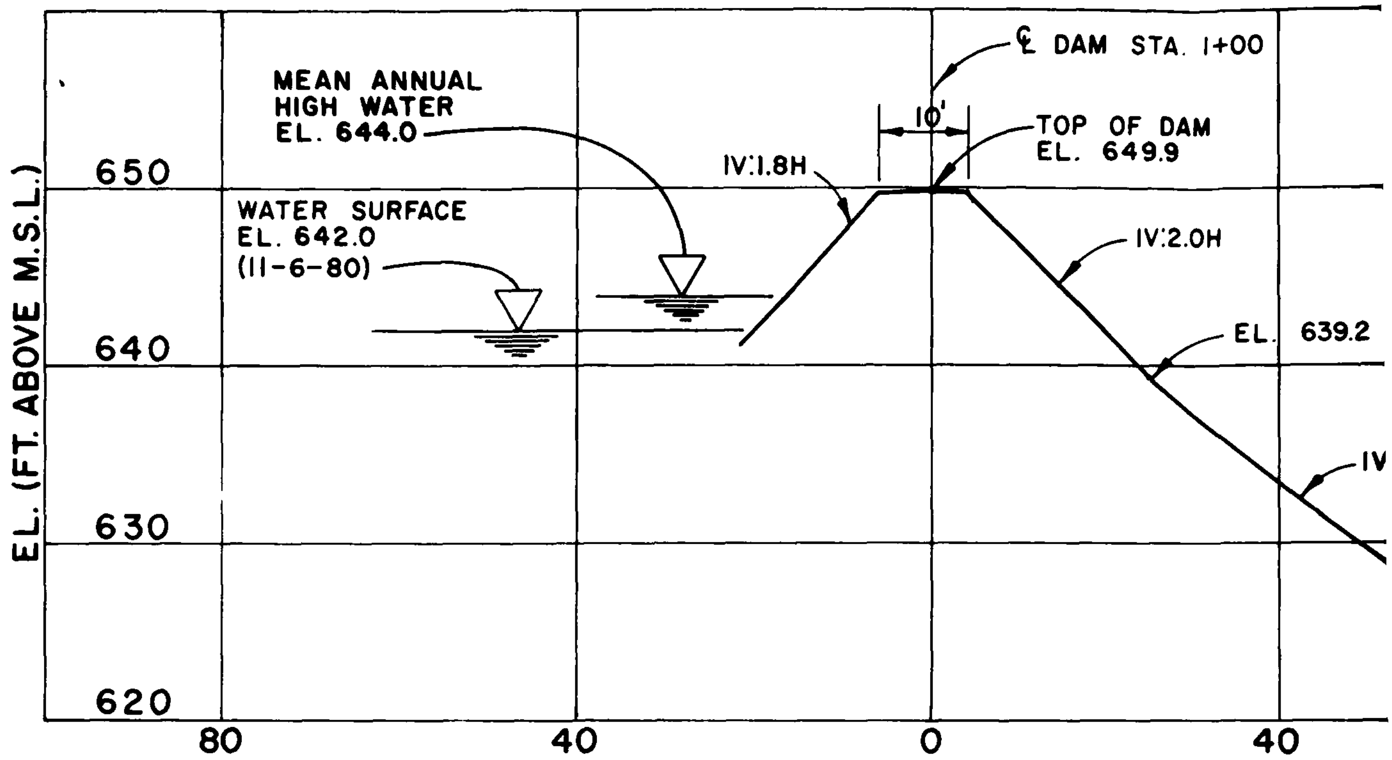


S-SECTION STA. 1+75

0' V., 1"=20' H.

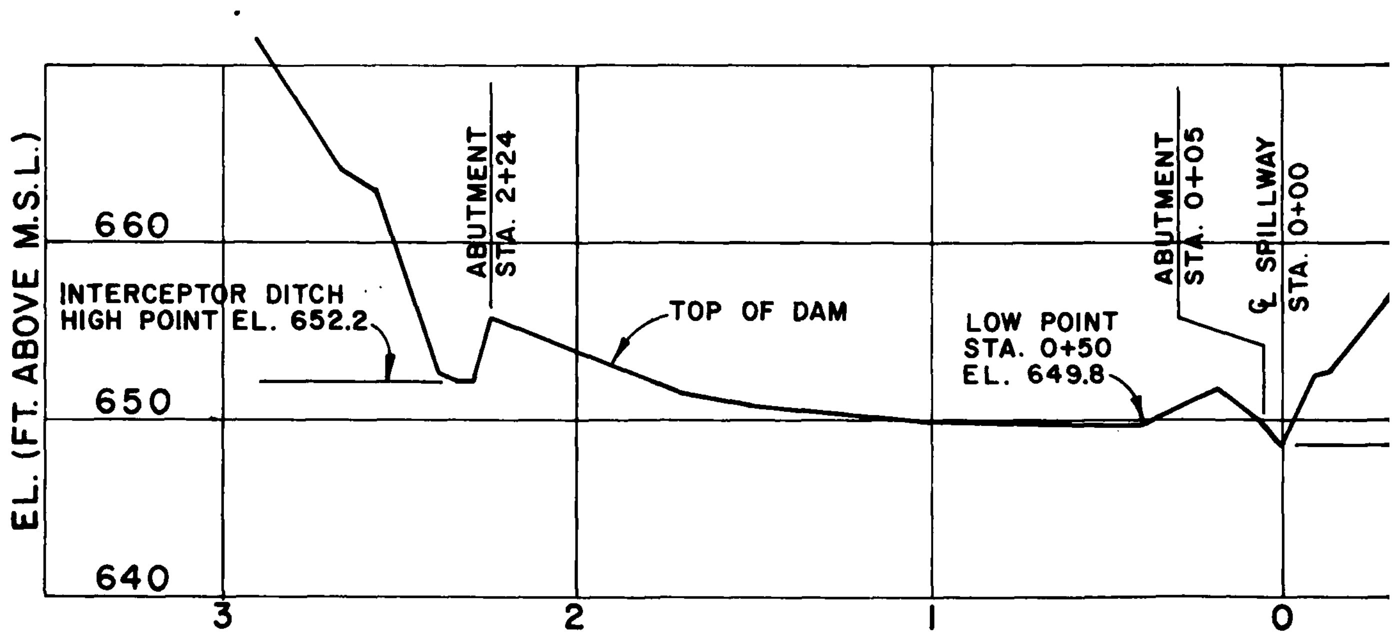
FRANCOIS LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILES

Horner & Shifrin, Inc. Jan. 1981



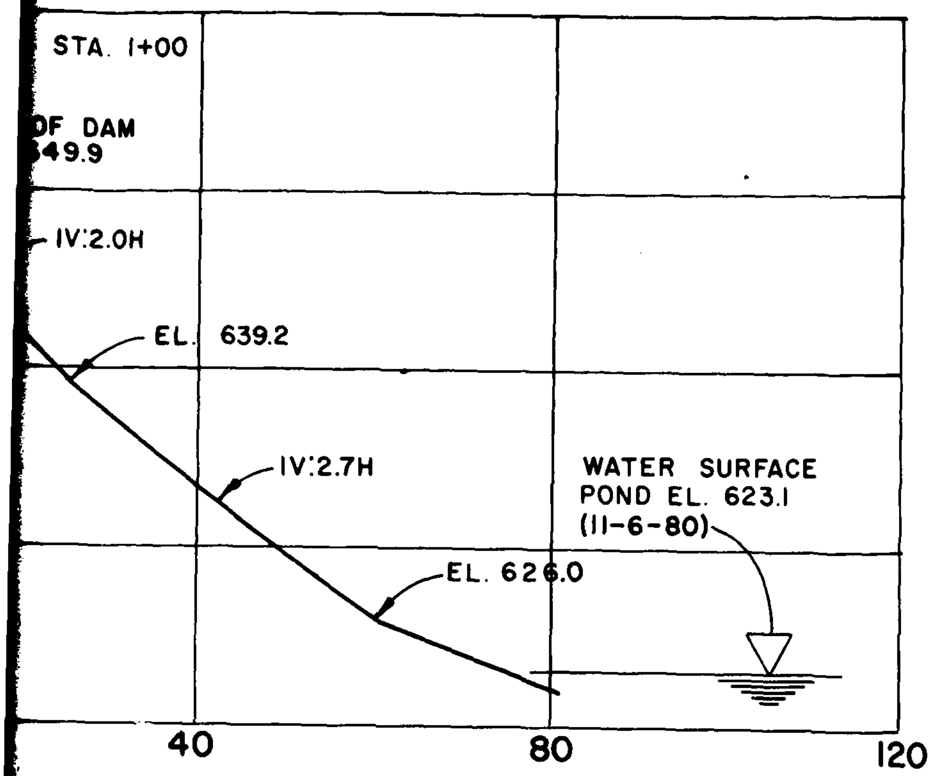
UPPER DAM CROSS-SECTION

SCALES: 1"=10'V., 1"=20'H.

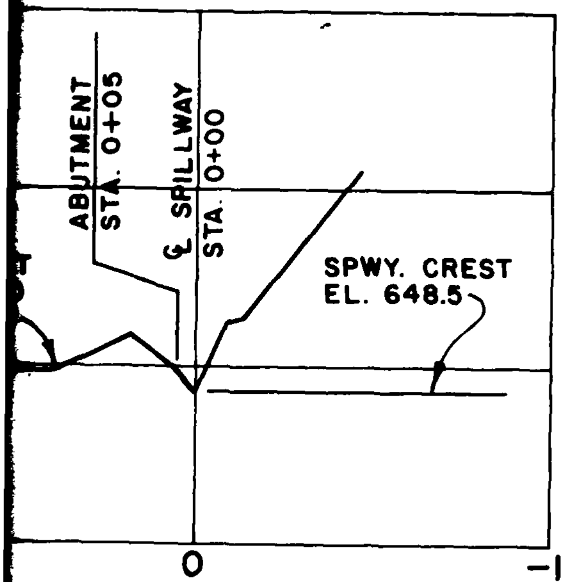


PROFILE-UPPER DAM CREST

SCALES: 1"=10'V., 1"=50'H.



TION

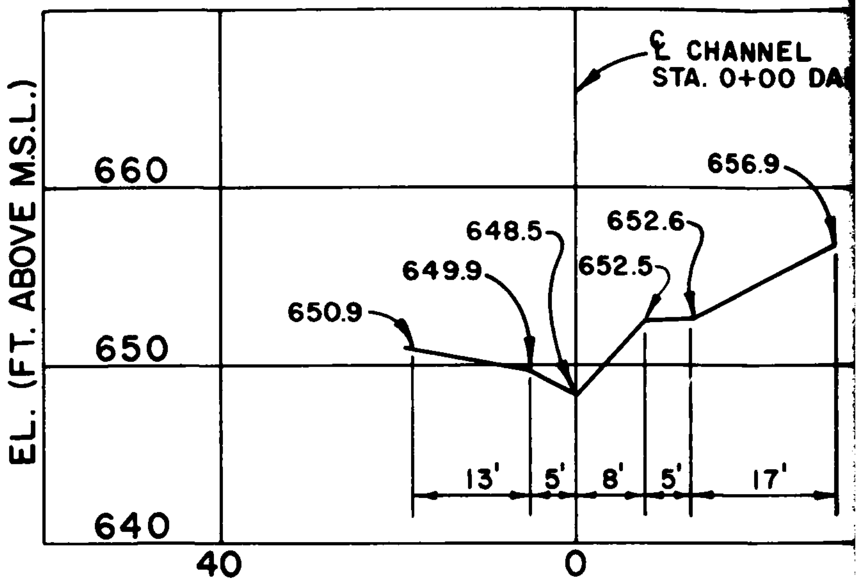


REST

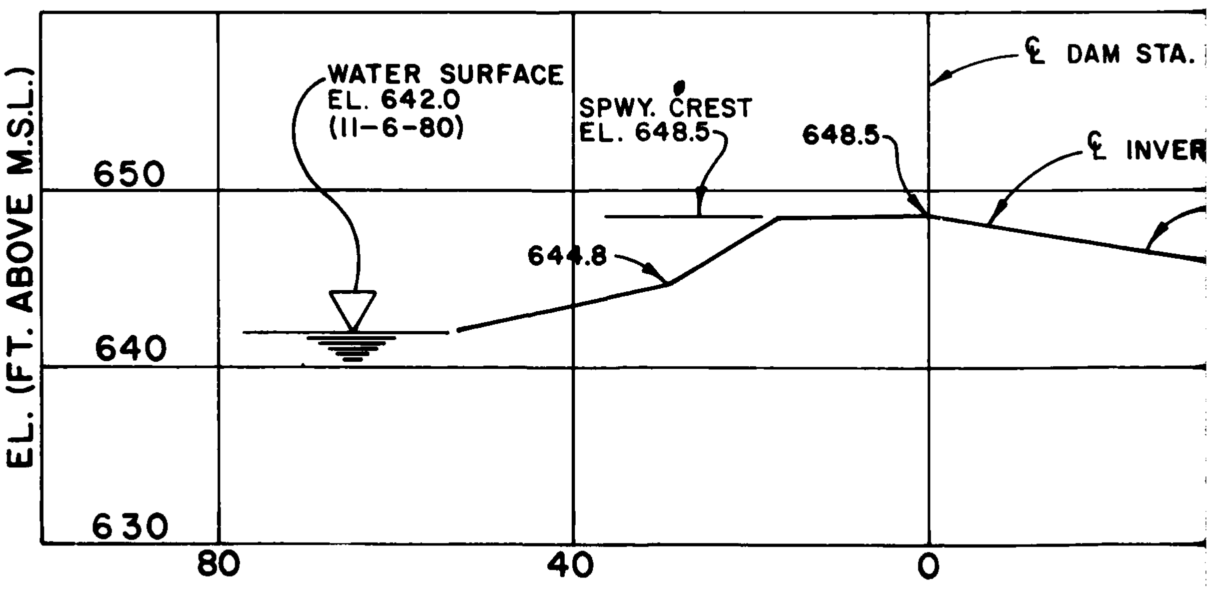
FRANCOIS LAKE
UPPER DAM PROFILE &
CROSS-SECTION
Horner & Shifrin, Inc. Jan. 1981

1 2

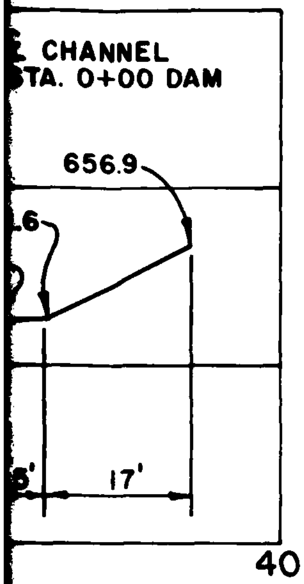
PLATE 5



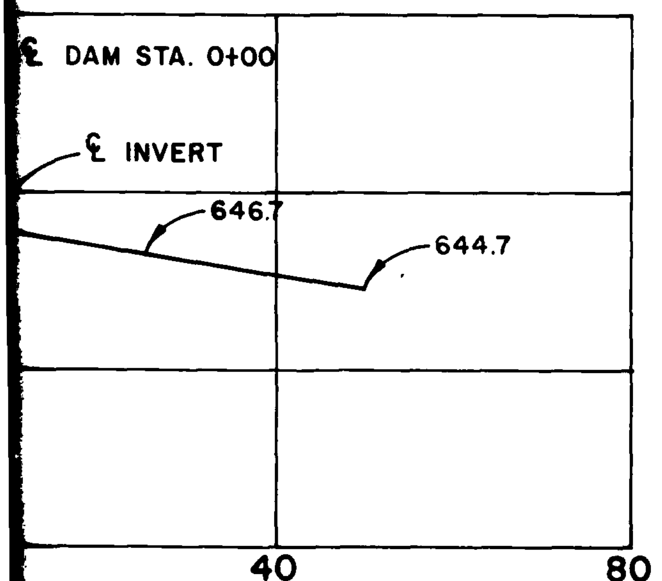
SPILLWAY CROSS-SECTION
SCALES: 1"=10'V., 1"=20'H.



SPILLWAY PROFILE
SCALES: 1"=10'V., 1"=20' H



SECTION
"=20'H.



FILE
20' H

FRANCOIS LAKE
UPPER DAM — SPILLWAY
PROFILE & CROSS-SECTION

Horner & Shifrin, Inc. Jan. 1981

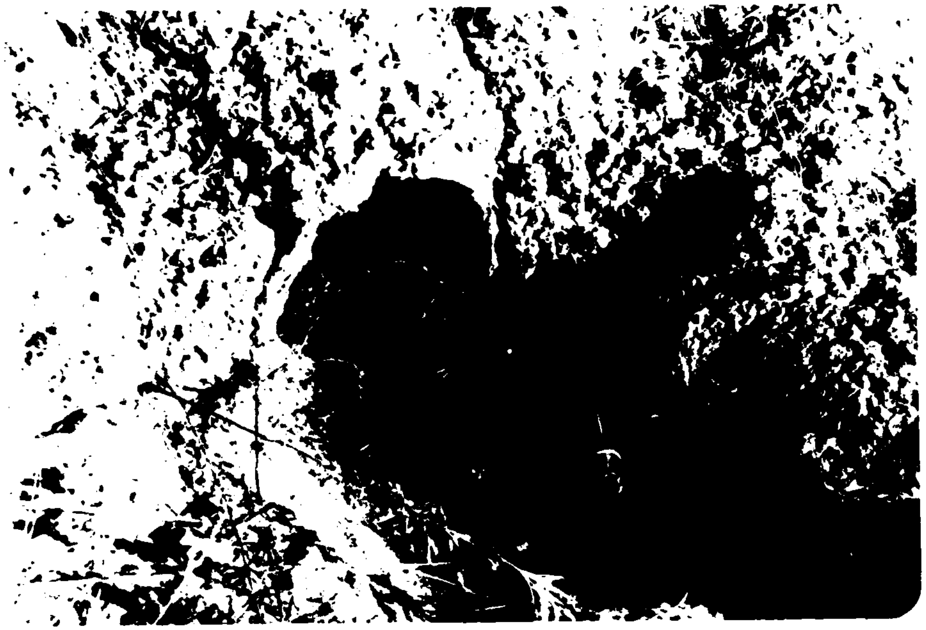
APPENDIX A

INSPECTION PHOTOGRAPHS

1	2
3	

PHOTO KEY

NO.	DESCRIPTION
1	DAM OVERVIEW
2	UPSTREAM FACE OF DAM
3	DOWNSTREAM FACE OF DAM



4	5
6	

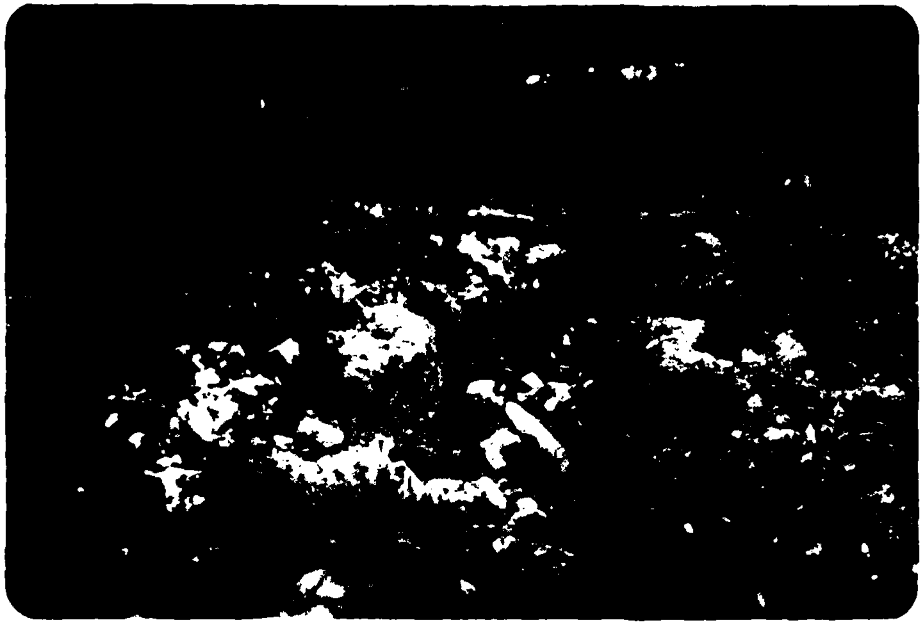
PHOTO KEY

NO.	DESCRIPTION
4	UPSTREAM END OF PRINCIPAL SPILLWAY
5	DOWNSTREAM END OF PRINCIPAL SPILLWAY
6	UPSTREAM END OF EMERGENCY SPILLWAY

7	8
9	

PHOTO KEY

NO.	DESCRIPTION
7	DOWNSTREAM END OF EMERGENCY SPILLWAY
8	OVERVIEW UPSTREAM DAM
9	OVERVIEW OF POND AND LAKE FROM UPSTREAM DAM



10	11
12	

PHOTO KEY

NO.	DESCRIPTION
10	EROSION GULLIES IN DOWNSTREAM FACE NEAR CREST OF DAM
11	EROSION GULLIES IN DOWNSTREAM FACE NEAR TOE OF DAM
12	EROSION GULLIES IN ROAD AT RIGHT ABUTMENT

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.5 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers.

b. Storm duration = 24 hours, unit hydrograph duration = 5 minutes

c. Drainage area:

(1) Upper Lake Dam = 0.052 square miles = 33.4 acres.

(2) Francois Lak Dam = 0.044 square miles = 27.8 acres (incremental)

d. SCS parameters:

(1) Francois Lake Dam.

Time of Concentration (T_C) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.032 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours

L = Length of longest watercourse = 0.123 miles

H = Elevation difference = 171 feet

Lag Time = 0.019 hours (0.60 Tc)

(2) Upper Lake Dam.

Time of Concentration (T_C) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.072 hours

Where: T_c = Travel time of water from hydraulically most distant point to point of interest, hours

L = Length of longest watercourse = 0.227 miles

H = Elevation difference = 132 feet

Lag Time = 0.043 hours (0.60 Tc)

(3) The time of concentration (T_c) for each dam was obtained using Method C as described in Figure 30, "Design of Small Dams", by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Hydrologic soil group = 100% D (Gasconade series, mostly wooded, per Mo. General Soil Map and field investigation)

Soil type CN = 77 (AMC II, 100-yr flood condition)
= 89 (AMC III, PMF condition)

2. Determination of spillway capacity:

a. Francois Lake Dam.

The spillway pipes were assumed to be flowing full.
Flow through the 12-inch and 30-inch diameter spillway pipes was computed using Bernoulli's equation for pressure flow in pipes. A friction factor (n) of 0.012 was used for the 12-inch asbestos-cement pipe and a friction factor of 0.021 was used for the 30-inch corrugated metal pipe. Losses, including entrance, pipe and exit losses totaled 3.2 velocity heads for the 12-inch pipe and 3.5 velocity heads for the 30-inch pipe. Reference "Handbook of Hydraulics", Fifth Edition, by King and Brater, pages 8-5 and 8-6.

b. Upper Lake Dam.

The trapezoidal spillway section consists of a broad-crested section, for which conventional weir formulas do not apply. Spillway release rates were determined as follows:

(1) Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

(2) It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth Q_c was computed as

$$Q_c = \left(\frac{a^3 g}{t}\right)^{0.5}$$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

(3) Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

3. The profile of each dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{{v_c}^2}{2g}$

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FRANCOIS LOWER LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B    288       0       5                                             0
B1     5
J      1       4       1
J1  0.19    0.20    0.50    1.00
K      0  INFLOW                                     1
K1       INFLOW HYDROGRAPH TO UPPER LAKE
M      1       2   0.052                     1.0                     1
P      0    25.5     102     120     130
T                                                   -1     -89
W2          0.043
X   -1.0    -.10     2.0
K      1  U. DAM                                     1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                  1       1
Y1     1                                   -648.50      -1
Y4 648.5  649.12  649.75  650.25  650.77  651.36  652.08  652.50  652.80  653.51
Y4653.65  653.80  654.55  655.30  656.05  656.80
Y5     0       2      11      26      55     113     215     284     342     503
Y5   539     579     798    1048    1335    1657
$A     0     1.1     1.8     2.0     3.2     4.5
$E 627.0   642.0   648.5     650     660     670
$$ 648.5
$D 649.8
```

PMF ANALYSIS - FRANCOIS LOWER LAKE DAM (Cont'd)

```
$L      0      60     132     152     160     165     178     197     224     238
$V  649.8   649.9   650.9   651.5   652.1   652.2   652.7   653.9   654.7   662.8
$B     10     0.5   636.0     1.0   648.5   649.8
K       0  INFLOW                                       1
K1       INFLOW HYDROGRAPH TO LOWER LAKE
M       1       2   0.044                     1.0                       1
P       0    25.5     102     120     130
T                                                      -1     -89
W2              0.019
X    -1.0    -.10     2.0
K       2   L DAM                                       1
K1       COMB. ROUTING  FROM UPPER LAKE & RUNOFF TO LOWER LAKE
K       1  L. DAM                                       1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                          26.07      -1
Y4  605.0   606.0   607.5   609.0   610.0   611.5   612.6   614.5   616.5   618.5
Y4  620.5   623.5   626.5   628.5
Y5      0       3       5       7      19      35    45.5    54.5      63      70
Y5     76      85      93      98
$A      0     3.4     4.2     5.7     7.4
$E  582.0     605     610     620     630
$$  605.0
$D  612.6
$L      0      71     153     313     335     359     433     467     505     571
$V  612.6   612.9   613.7   614.1   614.3   614.9   617.6   620.3   623.9   628.3
K      99
```

```
A1       ANALYSIS OF DAM OVERTOPPING USING 1 PERCENT CHANCE FLOOD
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF FRANCOIS LOWER LAKE DAM
A3       1 PERCENT CHANCE FLOOD ROUTED THROUGH RESERVOIR
B     288       0       5                                                4
B1      5
J       1       1       1
J1   1.00
K       0  INFLOW                                         1
K1       INFLOW HYDROGRAPH TO UPPER LAKE
M       0       2   0.052                     1.0                        1
O     288   6.974
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .023    .023
01   .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
01   .023    .023    .023    .023    .023    .023    .030    .030    .030    .030
01   .030    .030    .048    .048    .048    .049    .049    .049    .134    .134
01   .134    .255    .255    .546    .817    .380    .255    .134    .134    .134
01   .049    .049    .049    .048    .048    .048    .030    .030    .030    .030
01   .030    .030    .023    .023    .023    .023    .023    .023    .023    .023
01   .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
01   .012    .012    .012    .012    .012    .012    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
01   .007    .007    .007    .007    .007    .007    .007    .007
```

1% CHANCE FLOOD ANALYSIS - FRANCOIS LOWER LAKE DAM (Cont'd)

```
T                                                                 -1     -77
W2          0.043
X     -1.0    -.10     2.0
K        1   U DAM                                                 1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                     1       1
Y1       1                                                   -644.83      -1
Y4 648.5  649.12  649.75  650.25  650.77  651.36  652.08  652.50  652.80  653.51
Y4653.65  653.80  654.55  655.30  656.05  656.80
Y5       0       2      11      26      55     113     215     284     342     503
Y5     539     579     798    1048    1335    1657
$A       0     1.1     1.8     2.0     3.2     4.5
$E 627.0   642.0   648.5     650     660     670
$$ 648.5
$D 649.8
$L       0      60     132     152     160     165     178     197     224     238
$V 649.8   649.9   650.9   651.5   652.1   652.2   652.7   653.9   654.7   662.8
K        0  INFLOW                                                 1
K1       INFLOW HYDROGRAPH TO LOWER LAKE
M        0       2   0.044                           1.0                     1
O     -288
T                                                                 -1     -77
W2          0.019
X     -1.0    -.10     2.0
K        2   L DAM                                                 1
K1       COMB. ROUTING  FROM UPPER LAKE & RUNOFF TO LOWER LAKE
K        1   L DAM                                                 1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                                     1       1
Y1       1                                                     26.07      -1
Y4 605.0   606.0   607.5   609.0   610.0   611.5   612.6   614.5   616.5   618.5
Y4 620.5   623.5   626.5   628.5
Y5       0       3       5       7      19      35    45.5    54.5      63      70
Y5      76      85      93      98
$A       0     3.4     4.2     5.7     7.4
$E 582.0     605     610     620     630
$$ 605.0
$D 612.6
$L       0      71     153     313     335     359     433     467     505     571
$V 612.6   612.9   613.7   614.1   614.3   614.9   617.6   620.3   623.9   628.3
K       99
```

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO LOWER LAKE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.04	0.00	.04	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.50	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-89.00	0.00	0.00

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .02

RECESSION DATA

STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

UNIT HYDROGRAPH 5 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .02 VOL= 1.00

253.	71.	14.	3.	0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.22	.21	.01	58.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.22	.21	.01	69.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.22	.21	.01	71.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.22	.21	.01	72.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.22	.21	.01	72.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.22	.21	.01	72.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.22	.21	.01	72.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.22	.21	.00	72.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.22	.21	.00	72.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.22	.21	.00	72.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.22	.21	.00	72.

END-OF-PERIOD FLOW (Cont'd)

1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.22	.21	.00	72.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.26	.00	83.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.26	.00	86.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.26	.26	.00	87.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.26	.26	.00	87.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.26	.26	.00	87.
1.01	1.30	18	.01	.00	.01	0.	1.01	13.30	162	.26	.26	.00	87.
1.01	1.35	19	.01	.00	.01	0.	1.01	13.35	163	.26	.26	.00	87.
1.01	1.40	20	.01	.00	.01	0.	1.01	13.40	164	.26	.26	.00	87.
1.01	1.45	21	.01	.00	.01	0.	1.01	13.45	165	.26	.26	.00	88.
1.01	1.50	22	.01	.00	.01	0.	1.01	13.50	166	.26	.26	.00	88.
1.01	1.55	23	.01	.00	.01	0.	1.01	13.55	167	.26	.26	.00	88.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.26	.26	.00	88.
1.01	2.05	25	.01	.00	.01	1.	1.01	14.05	169	.33	.32	.00	104.
1.01	2.10	26	.01	.00	.01	1.	1.01	14.10	170	.33	.32	.00	109.
1.01	2.15	27	.01	.00	.01	1.	1.01	14.15	171	.33	.32	.00	110.
1.01	2.20	28	.01	.00	.01	1.	1.01	14.20	172	.33	.32	.00	110.
1.01	2.25	29	.01	.00	.01	1.	1.01	14.25	173	.33	.32	.00	110.
1.01	2.30	30	.01	.00	.01	1.	1.01	14.30	174	.33	.32	.00	110.
1.01	2.35	31	.01	.00	.01	1.	1.01	14.35	175	.33	.32	.00	110.
1.01	2.40	32	.01	.00	.01	1.	1.01	14.40	176	.33	.32	.00	110.
1.01	2.45	33	.01	.00	.01	1.	1.01	14.45	177	.33	.32	.00	110.
1.01	2.50	34	.01	.00	.01	1.	1.01	14.50	178	.33	.32	.00	110.
1.01	2.55	35	.01	.00	.01	1.	1.01	14.55	179	.33	.32	.00	110.
1.01	3.00	36	.01	.00	.01	1.	1.01	15.00	180	.33	.32	.00	110.
1.01	3.05	37	.01	.00	.01	2.	1.01	15.05	181	.20	.20	.00	78.
1.01	3.10	38	.01	.00	.01	2.	1.01	15.10	182	.40	.39	.00	119.
1.01	3.15	39	.01	.00	.01	2.	1.01	15.15	183	.40	.39	.00	131.
1.01	3.20	40	.01	.01	.01	2.	1.01	15.20	184	.59	.59	.00	183.
1.01	3.25	41	.01	.01	.01	2.	1.01	15.25	185	.69	.69	.00	223.
1.01	3.30	42	.01	.01	.01	2.	1.01	15.30	186	1.68	1.67	.01	481.
1.01	3.35	43	.01	.01	.01	2.	1.01	15.35	187	2.77	2.76	.01	828.
1.01	3.40	44	.01	.01	.01	2.	1.01	15.40	188	1.09	1.08	.00	495.
1.01	3.45	45	.01	.01	.01	2.	1.01	15.45	189	.69	.69	.00	294.
1.01	3.50	46	.01	.01	.01	2.	1.01	15.50	190	.59	.59	.00	221.
1.01	3.55	47	.01	.01	.01	2.	1.01	15.55	191	.40	.39	.00	154.
1.01	4.00	48	.01	.01	.01	2.	1.01	16.00	192	.40	.39	.00	138.
1.01	4.05	49	.01	.01	.01	2.	1.01	16.05	193	.30	.30	.00	112.
1.01	4.10	50	.01	.01	.01	2.	1.01	16.10	194	.30	.30	.00	105.
1.01	4.15	51	.01	.01	.01	2.	1.01	16.15	195	.30	.30	.00	103.
1.01	4.20	52	.01	.01	.01	2.	1.01	16.20	196	.30	.30	.00	103.
1.01	4.25	53	.01	.01	.01	2.	1.01	16.25	197	.30	.30	.00	103.
1.01	4.30	54	.01	.01	.01	2.	1.01	16.30	198	.30	.30	.00	103.
1.01	4.35	55	.01	.01	.01	2.	1.01	16.35	199	.30	.30	.00	103.
1.01	4.40	56	.01	.01	.01	2.	1.01	16.40	200	.30	.30	.00	103.
1.01	4.45	57	.01	.01	.01	3.	1.01	16.45	201	.30	.30	.00	103.
1.01	4.50	58	.01	.01	.01	3.	1.01	16.50	202	.30	.30	.00	103.
1.01	4.55	59	.01	.01	.01	3.	1.01	16.55	203	.30	.30	.00	103.

END-OF-PERIOD FLOW (Cont'd)

1.01	5.00	60	.01	.01	.01	3.	1.01	17.00	204	.30	.30	.00	103.
1.01	5.05	61	.01	.01	.01	3.	1.01	17.05	205	.24	.24	.00	87.
1.01	5.10	62	.01	.01	.01	3.	1.01	17.10	206	.24	.24	.00	82.
1.01	5.15	63	.01	.01	.01	3.	1.01	17.15	207	.24	.24	.00	81.
1.01	5.20	64	.01	.01	.01	3.	1.01	17.20	208	.24	.24	.00	81.
1.01	5.25	65	.01	.01	.01	3.	1.01	17.25	209	.24	.24	.00	81.
1.01	5.30	66	.01	.01	.01	3.	1.01	17.30	210	.24	.24	.00	81.
1.01	5.35	67	.01	.01	.01	3.	1.01	17.35	211	.24	.24	.00	81.
1.01	5.40	68	.01	.01	.01	3.	1.01	17.40	212	.24	.24	.00	81.
1.01	5.45	69	.01	.01	.01	3.	1.01	17.45	213	.24	.24	.00	81.
1.01	5.50	70	.01	.01	.01	3.	1.01	17.50	214	.24	.24	.00	81.
1.01	5.55	71	.01	.01	.01	3.	1.01	17.55	215	.24	.24	.00	81.
1.01	6.00	72	.01	.01	.01	3.	1.01	18.00	216	.24	.24	.00	81.
1.01	6.05	73	.06	.04	.02	11.	1.01	18.05	217	.02	.02	.00	76.
1.01	6.10	74	.06	.04	.02	14.	1.01	18.10	218	.02	.02	.00	71.
1.01	6.15	75	.06	.04	.02	14.	1.01	18.15	219	.02	.02	.00	66.
1.01	6.20	76	.06	.04	.02	15.	1.01	18.20	220	.02	.02	.00	61.
1.01	6.25	77	.06	.05	.02	15.	1.01	18.25	221	.02	.02	.00	57.
1.01	6.30	78	.06	.05	.02	16.	1.01	18.30	222	.02	.02	.00	53.
1.01	6.35	79	.06	.05	.02	16.	1.01	18.35	223	.02	.02	.00	50.
1.01	6.40	80	.06	.05	.02	16.	1.01	18.40	224	.02	.02	.00	47.
1.01	6.45	81	.06	.05	.01	17.	1.01	18.45	225	.02	.02	.00	43.
1.01	6.50	82	.06	.05	.01	17.	1.01	18.50	226	.02	.02	.00	41.
1.01	6.55	83	.06	.05	.01	17.	1.01	18.55	227	.02	.02	.00	38.
1.01	7.00	84	.06	.05	.01	17.	1.01	19.00	228	.02	.02	.00	35.
1.01	7.05	85	.06	.05	.01	17.	1.01	19.05	229	.02	.02	.00	33.
1.01	7.10	86	.06	.05	.01	18.	1.01	19.10	230	.02	.02	.00	31.
1.01	7.15	87	.06	.05	.01	18.	1.01	19.15	231	.02	.02	.00	29.
1.01	7.20	88	.06	.05	.01	18.	1.01	19.20	232	.02	.02	.00	27.
1.01	7.25	89	.06	.05	.01	18.	1.01	19.25	233	.02	.02	.00	25.
1.01	7.30	90	.06	.05	.01	18.	1.01	19.30	234	.02	.02	.00	23.
1.01	7.35	91	.06	.05	.01	18.	1.01	19.35	235	.02	.02	.00	22.
1.01	7.40	92	.06	.05	.01	19.	1.01	19.40	236	.02	.02	.00	20.
1.01	7.45	93	.06	.05	.01	19.	1.01	19.45	237	.02	.02	.00	19.
1.01	7.50	94	.06	.06	.01	19.	1.01	19.50	238	.02	.02	.00	18.
1.01	7.55	95	.06	.06	.01	19.	1.01	19.55	239	.02	.02	.00	16.
1.01	8.00	96	.06	.06	.01	19.	1.01	20.00	240	.02	.02	.00	15.
1.01	8.05	97	.06	.06	.01	19.	1.01	20.05	241	.02	.02	.00	14.
1.01	8.10	98	.06	.06	.01	19.	1.01	20.10	242	.02	.02	.00	13.
1.01	8.15	99	.06	.06	.01	19.	1.01	20.15	243	.02	.02	.00	12.
1.01	8.20	100	.06	.06	.01	19.	1.01	20.20	244	.02	.02	.00	12.
1.01	8.25	101	.06	.06	.01	19.	1.01	20.25	245	.02	.02	.00	11.
1.01	8.30	102	.06	.06	.01	19.	1.01	20.30	246	.02	.02	.00	10.
1.01	8.35	103	.06	.06	.01	20.	1.01	20.35	247	.02	.02	.00	9.
1.01	8.40	104	.06	.06	.01	20.	1.01	20.40	248	.02	.02	.00	9.
1.01	8.45	105	.06	.06	.01	20.	1.01	20.45	249	.02	.02	.00	8.
1.01	8.50	106	.06	.06	.01	20.	1.01	20.50	250	.02	.02	.00	8.
1.01	8.55	107	.06	.06	.01	20.	1.01	20.55	251	.02	.02	.00	7.
1.01	9.00	108	.06	.06	.01	20.	1.01	21.00	252	.02	.02	.00	7.
1.01	9.05	109	.06	.06	.01	20.	1.01	21.05	253	.02	.02	.00	7.

END-OF-PERIOD FLOW (Cont'd)

1.01	9.10	110	.06	.06	.01	20.	1.01	21.10	254	.02	.02	.00	7.
1.01	9.15	111	.06	.06	.00	20.	1.01	21.15	255	.02	.02	.00	7.
1.01	9.20	112	.06	.06	.00	20.	1.01	21.20	256	.02	.02	.00	7.
1.01	9.25	113	.06	.06	.00	20.	1.01	21.25	257	.02	.02	.00	7.
1.01	9.30	114	.06	.06	.00	20.	1.01	21.30	258	.02	.02	.00	7.
1.01	9.35	115	.06	.06	.00	20.	1.01	21.35	259	.02	.02	.00	7.
1.01	9.40	116	.06	.06	.00	20.	1.01	21.40	260	.02	.02	.00	7.
1.01	9.45	117	.06	.06	.00	20.	1.01	21.45	261	.02	.02	.00	7.
1.01	9.50	118	.06	.06	.00	20.	1.01	21.50	262	.02	.02	.00	7.
1.01	9.55	119	.06	.06	.00	20.	1.01	21.55	263	.02	.02	.00	7.
1.01	10.00	120	.06	.06	.00	20.	1.01	22.00	264	.02	.02	.00	7.
1.01	10.05	121	.06	.06	.00	20.	1.01	22.05	265	.02	.02	.00	7.
1.01	10.10	122	.06	.06	.00	20.	1.01	22.10	266	.02	.02	.00	7.
1.01	10.15	123	.06	.06	.00	20.	1.01	22.15	267	.02	.02	.00	7.
1.01	10.20	124	.06	.06	.00	21.	1.01	22.20	268	.02	.02	.00	7.
1.01	10.25	125	.06	.06	.00	21.	1.01	22.25	269	.02	.02	.00	7.
1.01	10.30	126	.06	.06	.00	21.	1.01	22.30	270	.02	.02	.00	7.
1.01	10.35	127	.06	.06	.00	21.	1.01	22.35	271	.02	.02	.00	7.
1.01	10.40	128	.06	.06	.00	21.	1.01	22.40	272	.02	.02	.00	7.
1.01	10.45	129	.06	.06	.00	21.	1.01	22.45	273	.02	.02	.00	7.
1.01	10.50	130	.06	.06	.00	21.	1.01	22.50	274	.02	.02	.00	7.
1.01	10.55	131	.06	.06	.00	21.	1.01	22.55	275	.02	.02	.00	7.
1.01	11.00	132	.06	.06	.00	21.	1.01	23.00	276	.02	.02	.00	7.
1.01	11.05	133	.06	.06	.00	21.	1.01	23.05	277	.02	.02	.00	7.
1.01	11.10	134	.06	.06	.00	21.	1.01	23.10	278	.02	.02	.00	7.
1.01	11.15	135	.06	.06	.00	21.	1.01	23.15	279	.02	.02	.00	7.
1.01	11.20	136	.06	.06	.00	21.	1.01	23.20	280	.02	.02	.00	7.
1.01	11.25	137	.06	.06	.00	21.	1.01	23.25	281	.02	.02	.00	7.
1.01	11.30	138	.06	.06	.00	21.	1.01	23.30	282	.02	.02	.00	7.
1.01	11.35	139	.06	.06	.00	21.	1.01	23.35	283	.02	.02	.00	7.
1.01	11.40	140	.06	.06	.00	21.	1.01	23.40	284	.02	.02	.00	7.
1.01	11.45	141	.06	.06	.00	21.	1.01	23.45	285	.02	.02	.00	7.
1.01	11.50	142	.06	.06	.00	21.	1.01	23.50	286	.02	.02	.00	7.
1.01	11.55	143	.06	.06	.00	21.	1.01	23.55	287	.02	.02	.00	7.
1.01	12.00	144	.06	.06	.00	21.	1.02	0.00	288	.02	.02	.00	7.
									SUM	33.15	31.71	1.44	11542.
										(842.)	(805.)	(37.)	(326.83)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	828.	122.	40.	40.	11548.
CMS	23.	3.	1.	1.	327.
INCHES		25.82	33.91	33.91	33.91
MM		655.90	861.30	861.30	861.30
AC-FT		61.	80.	80.	80.
THOUS CU M		75.	98.	98.	98.

UPPER FRANCOIS LAKE DAM

SURFACE AREA=	0.	1.	2.	2.	3.	5.
CAPACITY=	0.	6.	15.	18.	43.	82.
ELEVATION=	627.	642.	649.	650.	660.	670.

LOWER FRANCOIS LAKE DAM

SURFACE AREA=	0.	3.	4.	6.	7.
CAPACITY=	0.	26.	45.	94.	160.
ELEVATION=	582.	605.	610.	620.	630.

SUMMARY OF DAM SAFETY ANALYSIS

PMF - UPPER LAKE DAM

....	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	648.50	648.50	649.80
STORAGE	15.	15.	17.
OUTFLOW	0.	0.	12.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.19	649.81	.01	17.	269.	.13	14.08	13.50
.20	649.82	.02	17.	269.	.15	13.98	13.42
.50	649.84	.04	17.	362.	.19	15.67	12.08
1.00	649.81	.01	17.	730.	.13	15.67	7.67

SUMMARY OF DAM SAFETY ANALYSIS

PMF - LOWER LAKE DAM

....	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	605.00	605.00	612.60
STORAGE	26.	26.	56.
OUTFLOW	0.	0.	46.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.19	612.56	0.00	56.	45.	0.00	16.33	0.00
.20	612.74	.14	57.	48.	1.83	16.25	0.00
.50	614.08	1.48	63.	604.	6.17	15.67	0.00
1.00	614.64	2.04	66.	1350.	8.00	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1% CHANCE FLOOD - UPPER LAKE DAM

....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	644.83	648.50	649.60
	STORAGE	9.	15.	17.
	OUTFLOW	0.	0.	12.

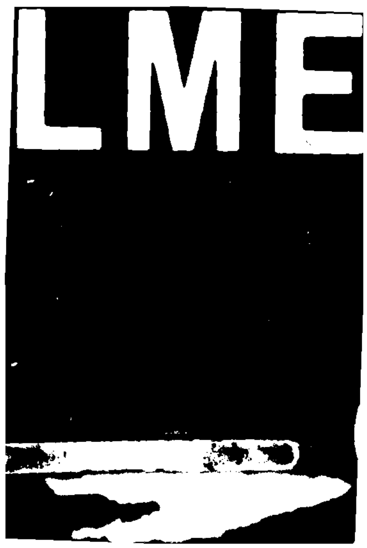
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	649.69	0.00	17.	10.	0.00	13.58	0.00

SUMMARY OF DAM SAFETY ANALYSIS

1% CHANCE FLOOD - LOWER LAKE DAM

....		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	605.00	605.00	612.60
	STORAGE	26.	26.	56.
	OUTFLOW	0.	0.	46.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	607.93	0.00	37.	6.	0.00	20.00	0.00


LME